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CREEL RETURNS FROM RUSH CREEK TEST STREAM, MONO COUNTY, CALIFORNIA, 1947-1951[1]

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INTRODUCTION

The rise in angling pressure on California's roadside trout waters since 1944 has been tremendous. Poorer catches have been accompanied by demands from the angling public for increased plants of catchable trout.[2] In response to these demands the California Department of Fish and Game is rapidly expanding hatchery production of "catchables." It is vitally important to get the greatest possible number of these expensive fish back into the anglers' creels. The Rush Creek experiments were designed to find out how this could be done in a representative stream in the great Inyo-Mono recreation area.

The experiments of the first five years, 1947 through 1951, dealt primarily with catchable rainbow trout. Smaller rainbow and brown trout were also planted during the first three years to determine their survival to following seasons, and to learn if such plants were more economical, in terms of fish in the angler's creel, than in-season plants of catchable trout.

This paper marks the completion of the rainbow trout phase of the project, the first four years of which were under the direction of the writer. Comparable experiments with brown trout are now under way.

DESCRIPTION OF THE TEST STREAM

The lower portion of Rush Creek was in many ways ideal for use as a test stream. Its location (Figure 1) in the Inyo-Mono vacationland only three miles from U. S. Highway 395 assured both heavy fishing and ready accessibility for planting. The stream was fairly typical of heavily fished trout streams on the east slope of the Sierra Nevada. Absence of tributaries prevented emigration of planted trout. The section available was large enough for heavy planting and yet, with but one access road, could be controlled from a single checking station with a minimum of personnel and facilities.

Rush Creek Test Stream is located in central Mono County of eastern California, four miles east of Lee Vining, about 10 miles east of the eastern boundary of Yosemite National Park, 67 miles north of Bishop, and 330 miles by good highway from Los Angeles. It includes 3.7 miles of lower Rush Creek from a rocky defile known locally as The Gorge downstream to the mouth of Rush Creek at Mono Lake (Figure 2).

[1] Submitted for publication January, 1954.
[2] In California there is no minimum size limit. The term "catchable" applies in this paper to trout about seven inches in length (or longer).

Trout are unable to live in Mono Lake because of its extremely high salinity. Gill-netting and observations during 1947 failed to indicate any loss of fish to Mono Lake, but as a precaution a weir and trap were installed in the delta section of Rush Creek early in 1948 and thereafter checked after each planting. Upstream migration was prevented by a seven-foot high rock-masonry barrier built in the center of The Gorge early in 1947.

Since the construction in 1939 of Grant Lake Dam and the Mono Tunnel by the City of Los Angeles for diversion of Mono Basin water

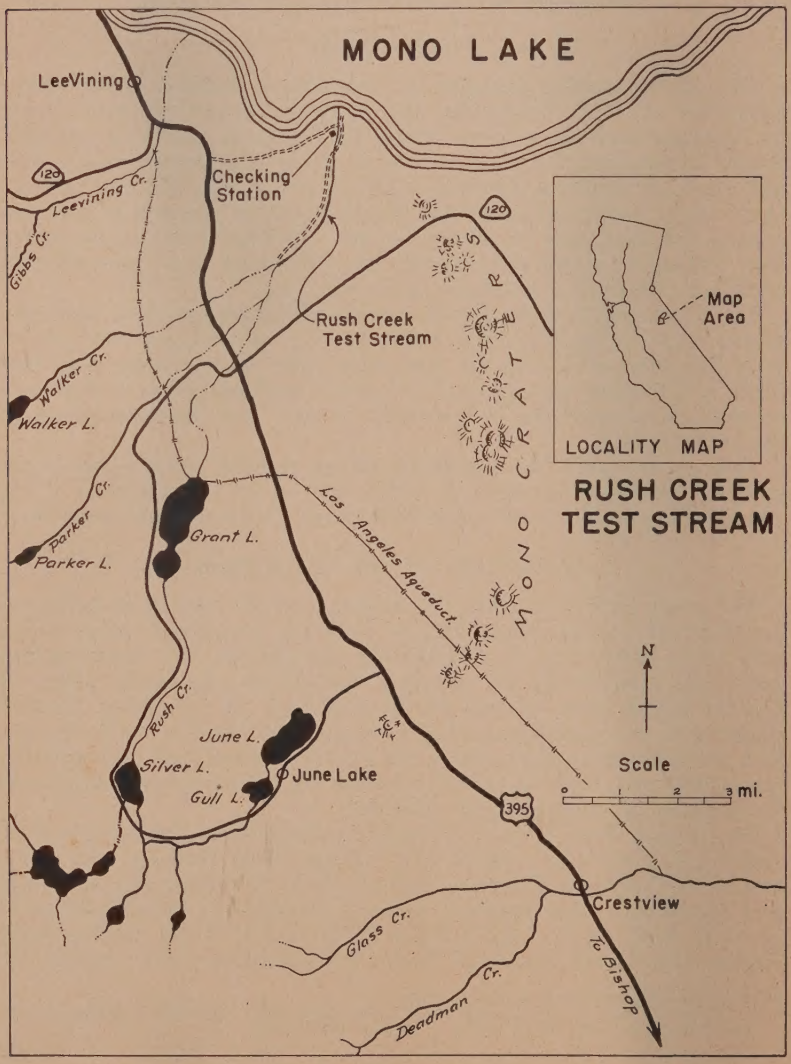

FIGURE 1. Location map of Rush Creek Test Stream, Mono County, California.

into the Los Angeles Aqueduct system, the natural flow in Rush Creek has been controlled and diverted. Tributaries of Rush Creek below the dam have also been diverted, by means of the Mono Basin Aqueduct. Since 1947 the City of Los Angeles has released no water into Rush Creek from Grant Lake Dam during the entire trout season. As a result the test stream at the upstream barrier was completely dry by late August in 1948 and by mid-July in 1949, and the entire summer flow has been supplied by the springs just below this barrier. Without water

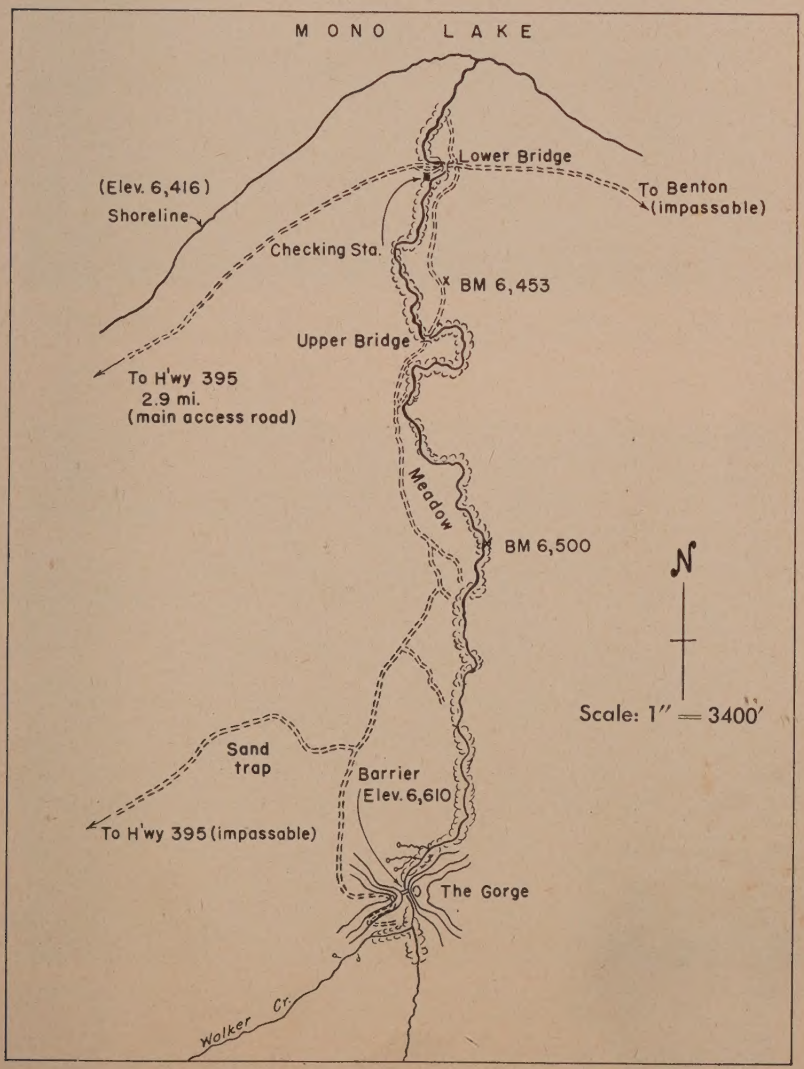

FIGURE 2. Map of Rush Creek Test Stream, Mono County.

to replenish water tables in the valley floor, these springs have declined steadily; the minimum flow in the test stream has fallen from 24 c.f.s. in 1947 to 12 c.f.s. in 1948, 13 c.f.s. in 1949, and 2 c.f.s. in 1950 and 1951. Mean flow during the 1951 season was only 2.5 c.f.s.

Prior to diversion the flow in lower Rush Creek normally reached spring maximum of about 175 c.f.s., but in very wet years it rose to more than 300 c.f.s. Spring run-off from Parker and Walker Creeks supplied some 50 c.f.s. of this total, and most of the rest was overflow from Grant Lake.

Lower Rush Creek formerly averaged about 20 feet in width during the trout season, with a depth of some seven inches on the riffles and four or five feet in the long delta pools. By 1951, however, these dimensions had been reduced by more than two-thirds.

The temperature of lower Rush Creek fluctuates daily during the summer between about 50 degrees and 70 degrees F., with trout season extremes of 37 degrees and 72 degrees F. in 1948 (Table 1). As the

TABLE 1

Average and Range in Temperatures at Rush Creek Test Stream, Season of 1948

Month	Air temp., deg. F.	Stream temp., deg. F.
March	38.8 (20-55)	47.1 (36-59)
April	48.7 (33-68)	52.0 (40-65)
May	57.1 (35-78)	56.1 (40-69)
June	65.4 (47-83)	59.0 (47-71)
July	73.9 (61-87)	60.0 (46-72)
August	72.6 (59-83)	59.0 (48-70)
September	65.9 (36-85)	53.9 (42-65)
October	53.9 (28-73)	47.7 (37-58)

flow has declined temperatures have shown somewhat greater extremes. Air and stream temperatures were recorded at the checking station at 8 a.m., 12 noon, and 4 p.m. daily.

Winter temperatures are often severe, although snowfall is rarely great enough to bridge the stream.

The gradient of the test section is moderate, with an average fall of 52 feet per mile. Riffles containing excellent spawning gravels make up the bulk of the test stream; pools are comparatively scarce. Rubble and boulders are found in The Gorge, while the delta section contains thick deposits of lapilli and pumiceous dust derived from the Mono Craters (Russell, 1889).[3]

In general, life-zone characteristics are those of Great Basin Upper Sonoran (Figure 3).[4]

[3] The test stream has not changed its course since the Tahoe glacial period. Till deposits from the Tahoe and Tioga periods underlie the surface blanket of ash and pumice sand from the Mono Craters, which flank the drainage on the east side. Rush Creek Gorge was cut through a shallow rhyolitic cap, and the sediment created a small flood plain below, across which lower Rush Creek now flows.

[4] Chief plant association of the Mono Basin is comprised of Three-toothed Sage (*Artemisia tridentata*) and Bitter Brush (*Purshia tridentata*). Lower Rush Creek streamside cover is characterized by dense jungles of willows (*Salix* sp.) interspersed with Black Cottonwoods (*Populus trichocarpa*), though open stretches are found at intervals along the low banks of the stream (Figure 4). Jeffrey Pines (*Pinus ponderosa* var. *jeffreyi*), once common, are still present in the vicinity of The Gorge.

FIGURE 3. Rush Creek Test Stream project area looking northeasterly from The Gorge. Mono Lake and Paoha Island in the background. *Photograph by Elden H. Vestal, April 10, 1947.*

FIGURE 4. Rush Creek Test Stream, Mono County, California. Section one-half mile above the upper bridge. *Photograph by Elden H. Vestal, May 2, 1948.*

Predators common to many streams in California are found along the test stream.[5]

Grazing animals are a nuisance at intervals during the trout season. Some 4,000 sheep are watered along the stream, roiling the water and causing a temporary decline in catches and angling effort.

HISTORY OF TROUT IN RUSH CREEK

Originally there were no trout in any of the streams of the Mono Basin. The first plants were reportedly made about 1880, and according to the "old-timers" of Lee Vining cutthroat trout and steelhead [6] were present in lower Rush Creek around the turn of the century. Brown Trout (*Salmo trutta*) fingerlings were introduced some 15 miles above the mouth probably in July, 1919. Eastern Brook Trout (*Salvelinus fontinalis*) and Lahontan Cutthroat Trout (*Salmo clarki henshawi*) were planted in 1931 and 1932, but apparently had little effect on the brown trout population, which was by that time said to be producing excellent fishing in lower Rush Creek. The fingerling brown trout plants continued until 1942, after which they were replaced by annual plants of unmarked catchable Rainbow Trout (*Salmo gairdneri*) until 1947 (Table 2).

TABLE 2

Fish Planting in Lower Rush Creek, 1940-1946

Species	Size	Number planted							
		1940	1941	1942	1943	1944	1945	1946	Total
Brown trout	Fingerling	11,520	10,010	------	------	------	------	------	21,530
Rainbow trout	Catchable	------	------	2,000	3,000	3,170	3,202	2,520	13,892
Grand total		------	------	------	------	------	------	------	35,422

TEST STREAM MANAGEMENT

The Planting Program, 1947-1951

Large plants of catchable rainbow trout were made in the test stream during each of the five years of this census period (Table 3). All of these trout were fall-spawning rainbow [7] which averaged about six fish per pound or seven inches in length. All were marked by the removal of one or more fins. Generally five plants of equal size were made each year a few days before the expected vacation angling peaks: opening day (May 1 or Saturday nearest thereto), Memorial Day, the Fourth of July, the middle of August, and Labor Day.

[5] Mink (*Mustela vison*) and Coon (*Procyon lotor*) are present. The Pallid Great Blue Heron (*Ardea herodias treganzai*) is an occasional visitor; one killed October 29, 1947, contained 21 newly planted fingerling rainbow and a 10-inch brown trout. American Mergansers (*Mergus merganser americanus*) have also been seen occasionally along the test stream. Pied-billed Grebes (*Podilymbus podiceps*), Eared Grebes (*Colymbus nigricollis californicus*), and California Gulls (*Larus californicus*) occur along the shore of Mono Lake, and probably capture a few trout in the delta section. The Wandering Garter Snake (*Thamnophis ordinoides vagrans*) is common along the stream during the summer and may take a few trout.

[6] Probably Lahontan Cutthroat Trout (*Salmo clarki henshawi*) and Steelhead Rainbow Trout (*Salmo g. gairdneri*).

[7] A strain developed at Hot Creek State Hatchery, California, by selective breeding.

TABLE 3

Rush Creek Test Stream Marking and Planting Program, 1947-1951: Catchable Rainbow

	1947	1948	1949	1950	1951
Number planted	10,000	19,945	19,975	10,000	9,984
Mark (fins removed)	LV	RV	Both V	RV	Both V
Dates of planting	5/13, 5/28, 6/23, 7/14, 8/4	4/28, 5/26, 6/23, 7/21, 8/11	4/29, 5/26, 6/23, 7/15, 8/4, 8/29	4/28, 5/26, 6/23, 7/15, 8/9	4/20, 5/24, 6/28, 8/2, 8/30
Average size in:					
Number per pound	6	6.7	5.6	6	6.3
Inches	7	7	7-1/2	7	7

V = ventral fin; L = left; R = right.

The 1947 plant of 10,000 catchables was increased to 20,000 in 1948 and 1949 in order to test the effect of larger plants on individual catches and total yield. In 1950 and 1951 stocking was restored to the 1947 level.

Two additional size classes of trout were used in planting experiments of the first three years: "subcatchables" and "fingerlings"[8] (Table 4). These were also all marked by fin removal.

In 1947 and 1948 equal numbers of spring-spawned and fall-spawned subcatchable rainbow were planted late in the season in an attempt to learn which strain gave greater over-winter survival.

The 1948 and 1949 fingerling plants of rainbow and brown trout were made for a comparison of the return of the two species to the angler. The small fingerling rainbow planted in 1948 were typical of fingerling rainbow planted in California streams at the time.

Subcatchables and fingerlings were not planted in 1950 and 1951, to prevent confusion of fin marks and to provide opportunity for the earlier plants to exhaust themselves in the catch.

All plants were distributed more or less equally throughout the test section, with the exception of the extreme upper and lower one-half miles, which were not accessible to the planting trucks.

Regulations

The test stream was operated in accordance with California's general summer trout angling regulations:

Season—May 1st or Saturday nearest thereto through October 31st.
Fishing hours—one-half hour before sunrise to one-half hour after sunset.
Bag and possession limit—15 trout.
No minimum size limit.

With the following exceptions and special regulations:

In 1948 a three-day test stream closure followed each of the four in-season plants of catchable rainbow.
In 1951 the test stream was closed at 7 p.m. daily.
Throughout the project, camping was not permitted in the test stream area.

[8] The term "subcatchable" and "fingerling" apply in this paper to trout about four inches and two inches long, respectively.

TABLE 4

Rush Creek Test Stream Marking and Planting Program, 1947-1951: Fingerling Rainbow and Brown Trout and Subcatchable Rainbow

Date of planting	Species	Mark	Number	Average size		Hatchery stock
				Number per ounce	Length in inches	
Fingerlings						
July 14, 1948	Rainbow	D	4,000	30	1¾	Mt. Whitney spring-spawned
July 20, 1948	Brown	LV	3,392	25	1¾	Rush Cr.-Mt. Whitney
Aug. 26, 1949	Brown	RV	3,003	13	2¼	Rush Cr.-Mt. Whitney
Aug. 29, 1949	Rainbow	LV	3,000	12	2¼	Mt. Whitney spring-spawned
Subcatchables						
Sept. 27, 1947	Rainbow	Ad-LV	2,000	2	4	Mt. Whitney spring-spawned
Sept. 27, 1947	Rainbow	Ad-RV	2,000	2	4	Mt. Whitney fall-spawned
Oct. 13, 1948	Rainbow	Ad-D	4,000	2	4	Mt. Whitney spring-spawned
Oct. 13, 1948	Rainbow	Ad	4,000	1.5	4½	Mt. Whitney fall-spawned

Ad = adipose fin; V = ventral fin; D = dorsal fin; L = left; R = right.

Recording the Data

Information obtained from anglers upon arrival at the checking station included name, address, and time of arrival. A combined map and information circular describing the test stream was given to each registrant. Illustrated signs along the stream called further attention to the fact that all planted trout were marked, and to the need for a complete creel check. Road signs directing anglers to Rush Creek were set up on U. S. Highway 395 at the June Lake Junction and the turn-off to the test stream.

As anglers left the test stream the checker recorded the time of departure, calculated the elapsed fishing time, and tabulated all trout by species and mark.

A total of 12,298 cars registered at the checking station during the first four seasons. Only 13, a small fraction of one percent, failed to check out. Since it is virtually impossible to reach or leave the test stream without passing the checking station, the creel census was for all practical purposes complete.

CREEL RETURNS

Creel returns from the test stream for the five seasons, 1947 through 1951, are summarized in Table 5. The test stream was fished on 875 of a total of 911 days which made up five legal angling seasons. A total of 33,431 anglers fished 118,408 hours and caught 65,935 wild and planted trout, 6,573 (10 percent) of which were unmarked wild fish and 59,362 (90 percent) marked hatchery fish.

Wild Trout

Of the 6,573 wild trout caught, 5,716 (87 percent) were brown trout, 791 (12 percent) rainbow trout, and 66 (1 percent) eastern brook trout. It is remarkable that the wild brown trout population was able to sustain itself in the face of the unusually heavy fishing pressure and continued competition with huge numbers of alien trout for food and living space. The wild populations of rainbow and eastern brook trout were not, judging by yearly catches, able to sustain themselves under such conditions.

Catchable Rainbow Trout

Of the total of 69,904 catchable rainbow planted, 57,863 were caught during the season of planting and 152 in following seasons (including 34 caught in 1952), for an over-all return to the creel of 58,015 or 83 percent (Table 6). The catches during the season in which the fish were planted averaged 82.8 percent, with a range of 70.5 percent in 1951 to 92.1 percent in 1948. Catchables caught in later fishing seasons added an inconsequential 0.2 percent to the total yield.

The excellent yields obtained at Rush Creek demonstrate conclusively the value of in-season, spaced plantings of catchable trout for maintaining reasonably good angling in a small, heavily fished stream. It is doubtful that satisfactory fishing can be maintained in such waters for any great number of anglers by any other method.

TABLE 5

Angling Data From Rush Creek Test Stream, 1947-1951

	1947	1948	1949	1950	1951	1947-1951 Combined	Yearly average
Length of season (days)	184	172	184	184	187	911	182
Number days fished	180	169	179	176	171	875	175
Number angler days	5,778	8,384	10,004	5,805	3,460	33,431	6,686
Total hours fished	19,569	31,962	36,417	19,070	11,390	118,408	23,682
Average angler day (hours)	3.4	3.8	3.6	3.3	3.3		3.5
Catchable trout planted	10,000	19,945	19,975	10,000	9,984	69,904	13,981
Catchable trout caught in season of planting	8,881	18,362	15,995	7,584	7,041	57,863	11,573
Percentage return to creel[1]	88.8	92.1	80.1	75.8	70.5	82.8	82.8
Catchable trout caught in seasons following planting[2]		11	17	13	77		
Subcatchable trout planted	4,000	8,000				12,000	
Subcatchable trout caught	128	694	171	1	0	994	
Percentage return to creel						8.3	
Fingerling trout planted		7,392	6,003			13,395	
Fingerling trout caught		20	180	148	38	386	
Percentage return to creel						2.9	
Total catch planted trout	9,009	19,087	16,363	7,746	7,157	59,362	11,872
Total catch wild trout	1,351	1,292	1,657	1,032	1,241	6,573	1,315
Brown trout[3]	1,104 (81.7%)	1,131 (87.5%)	1,373 (82.9%)	938 (90.9%)	1,170 (94.3%)	5,716	1,143 (87.0%)
Rainbow trout[3]	214 (15.8%)	140 (10.8%)	279 (16.8%)	92 (8.9%)	66 (5.3%)	791	158 (12.0%)
Eastern brook trout[3]	33 (2.4%)	21 (1.6%)	5 (0.3%)	2 (0.2%)	5 (0.4%)	66	13 (1.0%)
Total catch all trout	10,360	20,379	18,020	8,778	8,398	65,935	13,187
Percentage planted trout	87.0	93.7	90.8	88.2	85.2		90.0
Percentage wild trout	13.0	6.3	9.2	11.8	14.8		10.0
Average catch per angler day	1.8	2.4	1.8	1.5	2.4		2.0
Average catch per angler hour	0.53	0.64	0.49	0.46	0.74		0.56
Number zero catches	2,855	3,287	4,150	2,497	1,682	14,471	2,894
Percentage zero catches	49.2	39.2	41.5	43.0	48.6		43.3

[1] In-season yield only; for **total yield**, see Table 6.
[2] 1952 catch includes 33 trout from 1951 plants and one from 1950 plants.
[3] With percentage of total wild trout catch.

TABLE 6

Returns of Catchable Rainbow to the Creel at Rush Creek From Plantings Made From 1947 to 1951

Year	Mark	Number planted	Yield to the creel						Total yield	Percent yield first season	Percent yield next season	Percent total yield to creel
			1947	1948	1949	1950	1951	1952				
1947	LV	10,000	8,881	11	1	0	0	0	8,893	88.8	0.11	88.9
1948	RV	19,945		18,362	16	0	0	0	18,378	92.1	0.08	92.2
1949	Both V	19,975			15,995	13	2	0	16,010	80.1	0.06	80.2
1950	RV	10,000				7,584	75	1	7,660	75.8	0.75	76.6
1951	Both V	9,984					7,041	33	7,074	70.5	0.33	70.8
Totals and averages		69,904	8,881	18,373	16,012	7,597	7,118	34	58,015	82.8	0.21	83.0

V = ventral fin; L = left; R = right.

Fingerling Rainbow and Brown Trout and Subcatchable Rainbow

The yield to the creel from summer-planted fingerling rainbow and brown trout and from fall-planted subcatchable rainbow during the census period is summarized in Table 7.

Only 386 (2.9 percent) of a total of 13,395 fingerlings planted were caught. Rainbow gave a slightly greater return (3.2 percent) than brown trout (2.6 percent) planted at the same time.

The somewhat larger subcatchables gave an appreciably greater return than the fingerlings: 994 (8.3 percent) of 12,000 subcatchables planted during the census period were caught. Although Table 7 apparently indicates superiority of the spring-spawned strain, with a 12.5 percent return, over the fall-spawned strain, with a 4.1 percent return, the data are inconclusive. In fact, nearly the entire difference between the yields of the two stocks arose from the fall, 1948 plants. Four thousand rainbows of each strain were planted on the same day, October 13th, and yet during the remaining 18 days of the fishing season 444 of the spring-spawned group and only three of the fall-spawned group were removed. The two plants were apparently made, contrary

TABLE 7

Returns of Fingerling Rainbow and Brown Trout and Subcatchable Rainbow Stocked in Rush Creek, 1947-1951 [1]

Mark	Time of plant	Number planted	Seasonal yield						Total yield	Yield in percent of total plant
			1947	1948	1949	1950	1951	1952		
Fingerlings										
Rainbow trout										
D	Summer, 1948	4,000	----	18	105	8	0	0	131	3.3
LV	Summer, 1949	3,000	----	----	0	87	3	0	90	3.0
Total		7,000	----	---	---	----	--	--	221	3.2
Brown trout										
LV	Summer, 1948	3,392	----	2	75	19	0	0	96	2.8
RV	Summer, 1949	3,003	----	----	0	34	35	0	69	2.3
Total		6,395	----	----	----	----	----	----	165	2.6
Total, all fingerlings		13,395	----	20	180	148	38	0	386	2.9
Subcatchables										
Rainbow trout (spring-spawned)										
Ad-LV	Fall, 1947	2,000	14	175	3	0	0	0	192	9.6
Ad-D	Fall, 1948	4,000	----	444	114	1	0	0	559	14.0
Total		6,000	----	---	----	-	---	---	751	12.5
Rainbow trout (fall-spawned)										
Ad-RV	Fall, 1947	2,000	114	72	0	0	0	0	186	9.3
Ad	Fall, 1948	4,000	----	3	54	0	0	0	57	1.4
Total		6,000	----	----	----	----	----	----	243	4.1
Total, all subcatchables		12,000	128	694	171	1	0	0	994	8.3

Ad = adipose fin; V = ventral fin; D = dorsal fin; L = left; R = right.

[1] For size of fish and dates of planting see Table 4.

to instructions, in different parts of the stream, and as a result were subjected to greatly different fishing intensities.

The low over-all return from the fingerling and subcatchable plants illustrates the impracticability of maintaining satisfactory angling by fall planting of trout in small, heavily fished streams.

Angling Intensity and Angling Success

During the five seasons of this census period each mile of the test stream supported an average of 10 anglers and 35 angling hours per day. Average catch per angler was 0.56 trout per hour and 2.0 trout per day. Forty-three percent of all anglers caught nothing, despite the heavy plants of catchable trout. Thus, most anglers still had only poor to fair fishing, with the bulk of the fish caught by a minority. This emphasizes the desirability of a reduced bag limit on waters under this type of management in order to distribute the fish more equitably

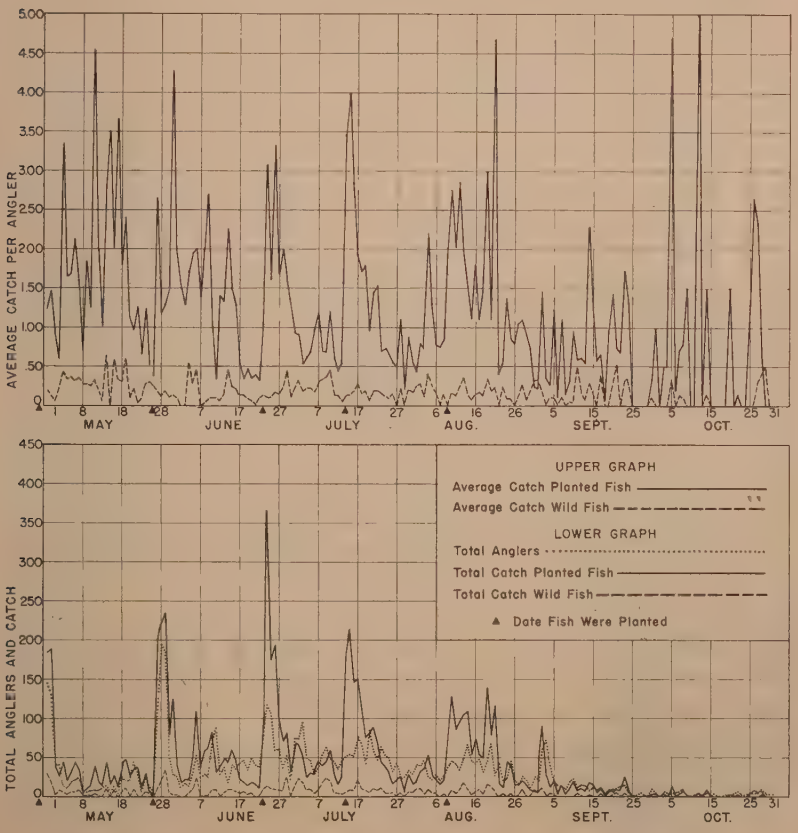

FIGURE 5. Graph of anglers' daily catches from Rush Creek Test Stream, Mono County, California, season of 1950.

and to give the less expert anglers a better opportunity to catch some of them.

Angling success (as measured by catch per day and catch per hour) varied somewhat from year to year (Table 5), apparently with little correlation with the size of the plant, the number of anglers, or the decreasing stream flow. It is probable, however, that angling success would have been greater in 1948 and 1949 if the increased plants in those years had not attracted correspondingly more anglers.

The catchables were normally recaptured very rapidly. This is shown strikingly by the graphs in Figure 5. In 1950, a typical year, 45 percent of the seasonal catch was taken during the five five-day periods immediately following stocking, which amounted to only one-seventh of the total fishing season. The plants gave the fishery a "shot in the arm," with a high yield for the first few days, followed by a diminishing catch until the next plant. Each plant also briefly increased the take of wild fish, and was followed shortly by a decrease in the catch of such fish as well.

In 1948 a special three-day post-planting closure was tested as a possible means of spreading the catch. It actually had the opposite effect, however, since reopening of the stream resulted in extraordinarily heavy fishing pressure. The percentage of return that season was the greatest recorded during the census.

The great increase in fishing intensity and success following stocking which occurred so consistently at the test stream suggests the desirability, particularly during the summer vacation season, of more frequent plants well-scattered along the stream. The stocking pattern for California streams is being shifted rapidly in this direction.

FIGURE 6. Anglers fishing the meadow section of Rush Creek Test Stream. *Photograph by Elden H. Vestal, May 2, 1948.*

RECREATIONAL VALUES

During the five-year period covered by this report, 33,431 days of angling were spent on Rush Creek. This recreation was primarily developed by stocking 70,000 catchable trout, at an estimated total cost of $10,500 (15 cents per fish). Without such stocking, fishing would have deteriorated early in the season each year.

The value of a day of trout angling is believed to be in the neighborhood of $10, on the basis of the costs to the fisherman, although accurate estimates for the Inyo-Mono area are not available. On that basis, recreational values exceeding $300,000 were sustained at Rush Creek over a five-year period with only $10,500 worth of fish.

ACKNOWLEDGMENTS

The Rush Creek project was fortunate in having the continued support of a number of persons and agencies. Mr. J. B. Clover, acting for the Finley Estate, has continually aided the project by making portions of the test site available from year to year. The writer is pleased to credit especially Mrs. Venita R. McPherson, former Supervisor of District 3, Mono County, and the Inyo and Mono County Boards of Supervisors for financial support in bridging Rush Creek and in access road maintenance from US Highway 395. The Inyo National Forest, the Nevada-California Electric Corporation, the Mono County Western Conservation Club, and interested residents of Lee Vining and June Lake aided in bridge construction and fish planting. The City of Los Angeles Department of Water and Power kindly provided stream flow records and granted access to city-owned portions of the stream.

Mr. Walter L. Dombrowski was employed as principal recorder at Rush Creek checking station from 1947 until the close of the 1949 season. Mr. Valjean Clark was recorder for the 1950 angling season and Mr. George Murphy was principal recorder in 1951. A succession of student biologists, including Messrs. John F. Williams, James R. King, Robert R. Ehlers, and Edwin Pister, aided these men.

The project benefited greatly from the guidance of Messrs. Alan C. Taft and Brian Curtis.

Mr. Ralph V. Beck assisted in operation of the checking station and marking of trout through the season of 1950. In 1951 Mr. Beck, under the supervision of Mr. Scott M. Soule, assumed direction of the project. The writer is grateful for the opportunity to incorporate the results of his work during the 1951 season in Table 5 of this paper.

SUMMARY

1. This paper reports results of the first five years (1947 through 1951) of a continuing complete creel census on Rush Creek Test Stream, a 3.7 mile section of a small California trout stream.
2. Rush Creek Test Stream was established by the California Department of Fish and Game to test the success of existing planting procedures and to find ways of improving them. Large in-season plants of marked catchable rainbow trout were made each year. Smaller plants of marked subcatchable rainbow trout and marked

fingerling rainbow and brown trout were made in the first three years to determine over-winter survival of such fish.

3. During the five-year census period, 33,431 anglers fished 118,408 hours and caught a total of 65,935 wild and planted trout. Planted trout contributed 59,362 (90 percent) of the total catch, while wild trout contributed 6,573 (10 percent).
4. The catch of wild brown trout remained about the same each year, despite the heavy fishing pressure, while the catch of wild rainbow and eastern brook trout declined.
5. Of 69,904 marked catchable rainbow planted, 58,015 (83 percent) were caught by anglers; 82.8 percent in the season of planting and 0.2 percent in succeeding seasons. This excellent yield demonstrates the value of in-season, spaced plantings of such fish for maintaining reasonably good angling in a small, heavily fished stream.
6. Of 13,395 fingerlings planted, only 386 (2.9 percent) were caught. Rainbow gave a slightly greater return (3.2 percent) than brown trout (2.6 percent). Of 12,000 subcatchables planted, 994 (8.3 percent) were caught. The spring-spawned strain gave a better return (12.5 percent) than the fall-spawned strain (4.1 percent), but data were insufficient to prove any superiority. These low returns illustrate the impracticability of maintaining angling in a small, heavily fished stream by stocking fry or subcatchables.
7. The five-year average intensity of use was 10 anglers and 35 angling hours per mile of stream per day.
8. Average catch per angler day was 2.0 and the average catch per angler hour was 0.56. The average angler day was 3.5 hours.
9. Forty-three percent of all anglers caught nothing, despite the heavy planting program. A reduced bag limit would probably distribute the fish more equitably and give the less expert anglers a better chance.
10. Catchables were recaptured rapidly. In 1950, a typical year, 45 percent of the total seasonal catch was taken in only one-seventh of the total fishing season. This suggests the desirability of more frequent plants well-scattered along the stream.
11. The estimated total cost of stocking 70,000 catchable rainbow trout during the five years of the census period was $10,500. Placing a value of $10 on a day of trout angling in the Mono-Inyo area of California (based on probable costs to the fisherman), a total recreational value exceeding $300,000 was sustained at Rush Creek mainly by this stocking.

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THE ECOLOGY OF ALAMITOS BAY, CALIFORNIA, WITH SPECIAL REFERENCE TO POLLUTION[1]

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INTRODUCTION

The fisheries resources of California's bays and estuaries are of considerable importance to both commercial and recreational interests. The maintenance and development of these resources is in large part dependent upon clean water, which is vital not only to fish and shellfish but also to the organisms on which they feed. For these reasons the California Department of Fish and Game has been interested in furthering studies which will add to our fund of knowledge about these waters and their inhabitants.

Recent investigations of marine harbors of Southern California include studies of Los Angeles-Long Beach Harbors (Anon., 1952a) and of San Diego Bay (Anon., 1952b) which were undertaken for the Los Angeles and San Diego Regional Water Pollution Control Boards. The portions of these reports on the bottom fauna were prepared by the authors and their associates. These bodies of water, which are used primarily for industrial and military purposes, were found to contain areas devoid of bottom-dwelling organisms ("zones of benthic sterility"). Here, sludge had accumulated in such quantities as to kill the existing bottom animals and to exclude their reintroduction. Since Alamitos Bay represents a bay in Southern California that is used only for recreational purposes, a survey of this area was undertaken for purposes of comparison with the industrial harbors. A second objective was to determine whether or not there was seepage of pollutants through the jetty separating the heavily polluted San Gabriel River from Alamitos Bay (Figure 1, Station 2).

Zones of pollution were described in the above-cited reports of Los Angeles-Long Beach Harbors and San Diego Bay as areas characterized by little or no dissolved oxygen in the water, the presence of black sulfide mud on the bottom, and the absence of large bottom organisms.

Quantitative studies of the fauna inhabiting the bottoms of bays and harbors of the eastern Pacific Ocean are few. The polychaete worms

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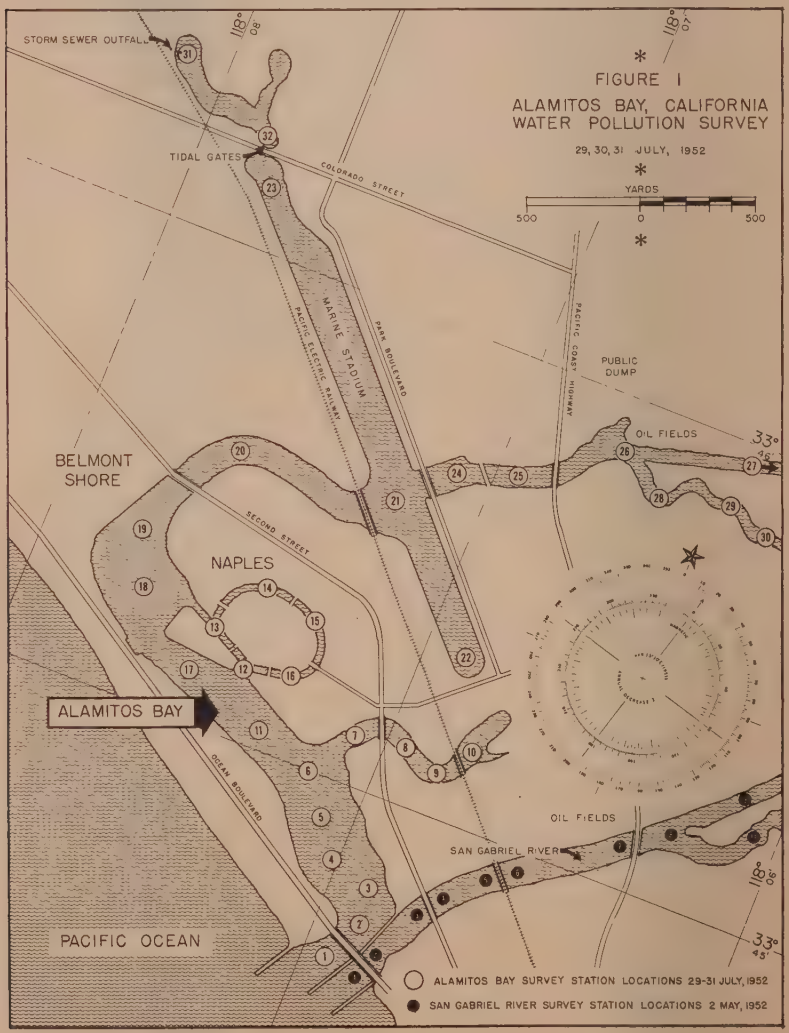
encountered in the benthos of Los Angeles-Long Beach Harbors were listed in the report cited above. The marine bottom communities of the Puget Sound, Washington, region have been described by Shelford and Towler (1925), Weese and MacNab (1930), and Shelford, et al. (1935). The ecology of Alamitos Bay has not been studied in the past.

DESCRIPTION AND HISTORY OF ALAMITOS BAY

The entrance to Alamitos Bay (Figure 1) is situated at the southeastern boundary of Los Angeles County, California. It is protected on both sides by rock jetties. The main channel is bordered on the ocean



side by a sand spit which is a residential section of the City of Long Beach and on the opposite side by the district of Naples of the City of Long Beach. Southeast of Naples there is a small side channel which extends about 1,000 yards. The main channel curves northward past the district of Belmont Shore and extends into the Marine Stadium. The northwest end of the Marine Stadium is separated from the bay by tidal gates at Colorado Street. This area, Colorado Lagoon, is used for swimming and bathing. The main channel of the bay extends northeast from the Marine Stadium and passes under the Pacific Coast Highway (U. S. Alternate 101). The channel divides into a north and a south branch.

Originally the area around Alamitos Bay was a marsh, with the San Gabriel River and Alamitos Bay sharing a common opening into the Pacific Ocean. Naples was laid out around 1908-1909 on a tidal flat, which was filled with material dredged from the bay. At first the homes connected with individual sewage disposal units, but following their annexation to the City of Long Beach, connections were made with the sewer lines of Long Beach. San Gabriel River and Alamitos Bay were separated from one another by a rock jetty (Figure 1, Stations 1 and 2) during the early 1920's. The Marine Stadium was dredged for the 1932 Olympic Games from tidal flats and marsh land. Originally the side channel southeast of Naples connected with the San Gabriel River, but during the flood of 1938 this connection was broken and the area was silted in. (Information supplied by the Los Angeles County Flood Control Office.)

MATERIALS AND METHODS

The investigation included temperature, dissolved oxygen, chlorinity, pH, transparency, and water depth readings in Alamitos Bay. Temperatures were taken just beneath the surface and recorded in degrees centigrade. Dissolved oxygen was determined in the field by the modified Winkler method (Welch, 1948, p. 207-209). Water samples were taken of the surface water for chlorinity determinations and analyzed by the Mohr method (Hill and Kofoid, 1927, p. 345-348). The pH of the surface water was measured in the field with a Beckman portable model 2-N pH meter furnished by the California State Department of Public Health. Transparency of the water was measured with a white Secchi disk 30 centimeters in diameter.

Samples of the substratum were taken with a Hayward orange-peel bucket size 1. This bucket sampled an area of 645 cm^2 (10 in. square); the volume of the sample varied usually from two to three liters, depending on the nature of the bottom. The sampler was covered with a canvas skirt to minimize the amount of washing by the water while the sample was being hauled to the surface. The sample was preserved intact in formalin. In the laboratory the volume of the sample was determined and the sample was screened through a mesh of 24 openings to the inch.

The animals were sorted into groups. The isopods and cumaceans were identified by Dr. Robert J. Menzies, Scripps Institution of Oceanography, the amphipods by Dr. J. Laurens Barnard, Department of

Zoology, University of Southern California, and the fishes by Miss Janet Haig, Allan Hancock Foundation. Assistance in the identification of the pelecypods was given by Mr. John E. Fitch, California Department of Fish and Game. The polychaete worms and all remaining organisms were identified by the senior author. This material has been deposited in the collections of the Allan Hancock Foundation.

CHEMICAL AND PHYSICAL DATA

The chemical and physical data are included in Table 3. The dissolved oxygen was over 5.0 ppm at all stations but 6, 27, 28, 29, and 30; however, at these stations there was at least 3.9 ppm. No visible signs of waste discharges were noted at Station 6, where the dissolved oxygen content was 4.8 ppm. Lumps of asphalt were observed at Station 27. The substratum at Stations 28, 29, and 30 possessed strong sulfide odor.

Water temperatures at the surface ranged from 20.0 to 27.0° C. (68.0°-80.6° F.). The maximum daily temperatures for the City of Long Beach were 27.5, 24.0, and 23.5° C. for July 29, 30, and 31, 1952, respectively.

The chlorinity at all stations was normal for sea water. No brackish water was encountered.

The transparency of the water, as measured by the Secchi disk, varied from 2.3 to 6.5 feet. The shallower readings were observed in the side channel (Stations 7 to 10) and north of the Pacific Coast Highway (U. S. Alternate 101) (Stations 26 to 30). The deeper readings were in the main channel.

The surface water was alkaline, ranging from pH 7.6 to 8.2.

NATURE OF THE SUBSTRATUM

The nature of the bottom was quite uniform throughout Alamitos Bay (Table 2). Most of the stations were characterized by fine grey mud which frequently contained pieces of plant material and shell fragments (Stations 3 to 19, 21 to 25, and 28 to 31). Station 32, at the Colorado Lagoon tidal gates, had a rocky bottom. The substratum was sandy at Stations 3, 22, 26, and 27. Bottom samples from Stations 28 to 31 possessed a strong sulfide odor. Stations 28 to 30 were in the vicinity of oil well drilling, and Station 31 was situated near a storm drainage outfall (Figure 1).

BOTTOM FAUNA

The benthic fauna of Alamitos Bay was found to be rich and varied, a total of 70 species of animals (Table 4) being collected. The polychaetes, crustaceans, and mollusks were well represented by 34, 15, and 13 species, respectively.

Strict comparisons can be made only with the polychaetes of Los Angeles-Long Beach Harbors (Anon., 1952a, p. 41). The same size orange-peel bucket was used in that survey and the present one. Slightly less than half the species of polychaetes were present in both regions. Alamitos Bay was particularly rich in the smaller polychaetes such as the spionids, while the larger forms were better represented in Los Ange-

les-Long Beach Harbors. A station check list of the species of animals taken from the benthos of Alamitos Bay is included in Table 5 to give some indication of the animal production of a marine body of water in Southern California that is not heavily polluted.

DISCUSSION

As evidenced by the survey of July 29, 30, and 31, 1952, there are several sources of materials deleterious to fish and aquatic life in Alamitos Bay, but none is considered to be serious at this time. No zones of benthic sterility or sludge beds were observed. There was no indication of seepage of pollutants from the San Gabriel River in the vicinity of Station 2.

Feces of the harbor seal, *Phoca vitulina* Linnaeus, were observed on the sandy beach in the vicinity of Station 5. However, it is believed that the harbor seal contributes little, if any, to pollution in the region, as evidenced by the low incidence of coliform organisms in the area (data on file at Department of Public Health, City of Long Beach). Station 5 was rich both in species and numbers of organisms present (Table 5).

Oil fields are located south of Stations 7 to 10, but there was no evidence of pollution in this side channel. Animals were abundant at these stations.

A public dump and oil fields are situated north of Station 26, but apparently have not affected the water, since this station was particularly rich in mollusks, polychaetes, and amphipod crustaceans (Table 5).

The north fork of Alamitos Bay in the vicinity of Station 27 has been dredged and many storm drains empty into it. The substratum had a thin clay layer with sand beneath. Lumps of asphalt were occasionally found in the sand; however, a large population of animals was present at this station.

Stations 28 to 30 were located in the vicinity of oil fields. The air at Station 30 was characterized by a petroleum odor. The substratum of these stations possessed a strong sulfide odor, but apparently pollution had not reached toxic levels, as evidenced by the animals present.

The tidal gates separating Colorado Lagoon from the Marine Stadium are opened once a week during the summer months to renew the water. During the winter these gates remain open. There is a storm drainage sewer outfall at the northwestern end. The substratum was black and possessed a strong sulfide odor at Station 31. This sample contained many shells of oysters that appeared to have died about the same time. Only three specimens each of the worm *Neanthes succinea* and the mollusk *Tagelus californianus* and one crab, *Hemigrapsus oregonensis*, were collected here. No living oysters were observed; apparently the pollutants had killed them.

SUMMARY

1. No conditions serious to fish and aquatic life exist in Alamitos Bay, California. Lumps of asphalt were observed in the substratum at Station 27. Samples of the substratum at Stations 28 to 30 were characterized by a strong sulfide odor, but no toxic conditions were observed. A strong sulfide odor was noted at Station 31 and oysters in the vicinity had been killed.
2. No sludge beds were discovered in Alamitos Bay.
3. No evidence of seepage of pollutants from the San Gabriel River into Alamitos Bay was discovered.
4. The substratum of Alamitos Bay supports a rich and varied fauna. This knowledge will be of particular value in comparing this region with the other harbors and bays of Southern California that are affected by domestic and industrial waste discharges.

TABLE 1

Alamitos Bay Station Locations

Station number	Descriptive location
1	Middle of channel 300 feet south of Ocean Street Bridge.
2	Middle of channel 150 feet north of Ocean Street Bridge.
3	Opposite the entrance of Alamitos Bay on the east side.
4	Middle of channel at the end of 70th Place.
5	Middle of channel at the end of 67th Place.
6	Middle of main channel opposite the mouth of the side channel.
7	Middle of side channel midway between mouth and Second Street Bridge.
8	Middle of side channel 300 feet east of Second Street Bridge.
9	Middle of side channel 300 feet south of Pacific Electric Bridge.
10	Middle of side channel 300 feet north of Pacific Electric Bridge.
11	Middle of channel at end of Silician Walk (bay side).
12	At entrance of the District of Naples canal system.
13	Middle of Naples Canal at west end of Rivo Alto Canal.
14	Middle of Rivo Alto Canal at end of Rivera Walk.
15	Middle of Rivo Alto Canal at end of Cordova Walk.
16	Middle of Rivo Alto Canal at end of Silician Walk (canal side).
17	Middle of channel at the end of Balboa Place.
18	Middle of channel opposite entrance of Naples Canal.
19	Middle of channel at end of Division Street.
20	Middle of channel at end of Broadway Street.
21	Middle of Marine Stadium in line with channel 400 feet from Park Boulevard Bridge
22	Northwest end of Marine Stadium.
23	Southeast end of Marine Stadium.
24	Middle of channel 300 feet northeast of Park Boulevard Bridge.
25	Middle of channel 400 feet southwest of Pacific Coast Highway (U. S. Alternate 101).
26	Middle of channel at junction of north and south forks 900 feet northeast of Pacific Coast Highway (U. S. Alternate 101).
27	Middle of north fork about 1,200 yards east of Pacific Coast Highway (U. S. Alternate 101).
28	Middle of south fork about 600 feet east of Pacific Coast Highway (U. S. Alternate 101).
29	Middle of south fork about 500 yards east of Pacific Coast Highway (U. S. Alternate 101).
30	Middle of south fork about 700 yards east of Pacific Coast Highway (U. S. Alternate 101), near the end of the south fork.
31	At the end of middle pier of Colorado Lagoon.
32	Lagoon side of tidal gates of Colorado Lagoon.

TABLE 2

Character of the Bottom

Station number	Volume of sample in cc.	Volume of animals in cc.	Character of bottom
1	No sample		
2	No sample		
3	710	3.0	Gray sand, small shell and gravel fragments
4	2,150	22.0	Fine mud, plant debris, shell fragments
5	1,675	42.0	Fine mud, plant debris, cantaloupe rind
6	3,200	28.0	Fine mud, plant debris, shell fragments
7	3,070	2.5	Fine mud, plant debris
8	2,150	150.0	Fine mud, plant debris
9	3,070	28.0	Fine mud, plant debris
10	3,200	30.0	Fine mud, plant debris, shell fragments
11	2,390	22.0	Fine mud, plant debris, shell fragments
12	2,950	5.0	Fine mud
13	2,850	5.0	Fine mud, plant debris, shell fragments
14	1,675	0.5	Fine mud, plant debris
15	2,390	8.0	Fine mud, plant debris
16	2,625	15.0	Fine mud, plant debris
17	1,400	1.5	Fine mud, plant debris, shell fragments
18	----	3.0	Fine mud, plant debris
19	2,390	2.0	Fine mud, gravel, plant debris, shell fragments
20	No sample		
21	2,625	1.5	Fine mud, plant debris, shell fragments
22	800	1.0	Sand, plant debris
23	2,390	100.0	Fine mud, gravel, shell fragments
24	2,850	1.0	Fine mud, plant debris
25	2,625	2.0	Fine mud, plant debris
26	1,200	60.0	Black sand, filamentous algae
27	1,675	2.0	Clay surface with sand beneath, asphalt
28	2,500	50.0	Fine mud, plant debris; strong sulfide odor
29	2,850	0.5	Fine mud, filamentous algae; strong sulfide odor
30	2,950	65.0	Fine mud, filamentous algae; slight sulfide odor, oil odor to water
31	2,550	10.0	Fine mud, oyster shells; strong sulfide odor, some oil present
32	25	25.0	Hard bottom

TABLE 3

Chemical and Physical Data

Station number	Time	Water depth in ft.	Transparency (Secchi-disk) in ft.	Temperature in °C.	Dissolved oxygen in p.p.m.	Chlorinity o/oo	pH
1	----	----	---	----	---	18.9	---
2	940	14.0	6.5	20.0	8.6	18.5	8.0
3	1047	15.0	5.5	20.9	6.8	18.7	8.2
4	1058	15.5	5.5	21.0	6.7	18.5	8.1
5	1107	15.0	5.5	21.0	7.1	18.5	8.0
6	1120	13.5	3.5	22.0	4.8	18.5	8.0
7	1130	12.0	2.5	22.0	6.1	18.5	7.9
8	1143	4.8	3.0	23.0	6.6	18.5	8.0
9	1220	2.8	2.3	23.0	5.4	18.5	8.0
10	1232	2.8	2.5	24.0	5.5	18.5	7.8
11	1410	18.0	4.5	20.5	7.2	----	8.1
12	1425	12.0	3.5	22.5	5.8	18.5	8.0
13	1436	12.5	3.5	24.0	7.6	18.7	8.0
14	1449	11.5	3.0	24.3	7.3	18.5	7.9
15	1505	11.0	2.5	24.0	7.2	18.7	8.0
16	1515	13.0	3.5	23.0	7.2	----	7.9
17	1648	22.0	4.5	24.5	7.7	18.7	7.8
18	1635	26.0	3.5	25.0	9.0	18.6	7.8
19	1625	27.0	3.3	24.0	7.7	18.4	7.8
20	1615	36.0	3.5	24.0	9.0	18.6	7.9
21	1401	17.0	3.5	25.0	9.1	18.7	7.9
22	1344	32.0	3.0	24.5	8.1	18.7	7.9
23	1322	14.0	4.5	26.0	8.0	18.5	7.8
24	1305	15.0	3.3	25.5	8.8	18.6	7.9
25	1241	14.5	3.3	25.5	8.5	18.6	7.9
26	1227	4.5	3.3	26.0	6.8	18.6	7.8
27	1137	4.0	3.3	26.5	4.5	18.7	7.6
28	1110	2.5	Bottom	26.0	3.9	18.7	7.6
29	1053	2.3	Bottom	26.0	4.0	18.7	7.7
30	1033	2.3	Bottom	25.5	4.6	18.7	7.9
31	1100	9.8	4.0	26.0	8.0	18.6	7.7
32	1200	15.0	4.0	27.0	9.1	18.6	7.8

NOTE: Stations 1-16 July 29, 1952
17-30 July 30, 1952
31-32 July 31, 1952
Chlorinity samples collected from shore October 30, 1952

Tides: July 29, 1952 High 126 (3.0 ft.) and 1356 (4.8 ft.)
Low 640 (2.0 ft.) and 2147 (1.6 ft.)
July 30, 1952 High 345 (2.7 ft.) and 1456 (5.1 ft.)
Low 715 (2.5 ft.) and 2310 (0.9 ft.)
July 31, 1952 High 625 (2.9 ft.) and 1605 (5.4 ft.)
Low 833 (2.8 ft.)

TABLE 4

List of Animals Collected From the Benthos of Alamitos Bay

Phylum Porifera
  Sponge colony

Phylum Platyhelminthes
  Turbellarians

Phylum Nermertea
  Nermerteans

Phylum Phoronidea
  Phoronids

Phylum Annelida
  Class Polychaeta
    Eteone dilatae Hartman
    Hypoeulalia bilineata (Johnston)
    Neanthes succinea (Frey and Leuckart)
    Nephtys caecoides Hartman
    Glycera americana Leidy
    Goniada littorea Hartman
    Lumbrineris minima Hartman
    L. erecta (Moore)
    Dorvillea articulatus (Hartman)
    Haploscoloplos elongata (Johnson)
    Prionospio near *malmgreni*
    P. near *kroyeri*
    P. pinnata Ehlers
    Nerinides acuta (Treadwell)
    Spiophanes missioniensis Hartman
    Spiophanes ?n. sp.
    Boccardia redeki (Horst)
    Polydora ligni Webster
    P. socialis Schmarda
    P. nuchalis Woodwick
    Streblospio benedicti Webster
    Spiochaetopterus ?n. sp.
    Magelona californica Hartman
    Cirriformia sp.
    Tharyx sp.
    Cossura longicirrata Webster and Benedict
    Capitita ambiseta Hartman
    Capitella capitata (Fabricius)
    Armandia bioculata Hartman
    Ampharete ?n. sp.
    Amphicteis scaphobranchiata Moore
    Pista cristata (Muller)
    P. alata Moore
    Hydroides norvegica (Gummerus)
  Class Oligochaeta
    Tubificids

Phylum Arthropoda
  Class Crustacea
    Order Amphipoda
      Corophium acherusicum Costa
      C. insidiosum Crawford
      Hyale sp.
      Elasmopus rapax Costa
      Phoxocephalid
      Pontharpinia sp.
      Caprellids
    Order Isopoda
      Edotea sp.
      Cirolanid
    Order Cumacea
      Oxyurostylis pacifica Zimmer

TABLE 4—Continued

List of Animals Collected From the Benthos of Alamitos Bay

Order Decapoda
Callianassa californiensis Dana
C. sp.
Shrimp
Cancer jordani Rathbun
Hemigrapsus oregonensis (Dana)

Phylum Mollusca
Class Gastropoda
Bullaria gouldiana (Pilsbry)
Crepidula sp.
Tephtys sp.
Class Pelecypoda
Tagelus californianus Conrad
Macoma nasuta Conrad
Solen rosaceus Carpenter
Chione undatella (Sowerby)
C. fluctifraga (Sowerby)
Laevicardium substriatum (Conrad)
Tellina buttoni Dall
T. carpenteri Dall
Saxidomus nuttalli Conrad
Ostrea lurida Carpenter

Phylum Echinodermata
Holothurians

Phylum Chordata
Tunicate colonies
Class Pisces
Clevelandia ios (Jordan and Gilbert)

TABLE 5

Identification of Animals

Station number	Species present	Number of specimens
1	No sample taken	
2	No sample taken	
3	Nermerteans	1
	Polychaetes	
	Nephtys caecoides	1
	Prionospio near *malmgreni*	32
	Nerinides acuta	2
	Magelona californica	1
	Tharyx sp.	1
	Capitita ambiseta	3
	Crustaceans	
	Caprellid	1
	Pontharpinia sp.	1
	Oxyurostylis pacifica	3
	Molluscans	
	Tagelus californianus	1
	Macoma nasuta	2
4	Turbellarian	1
	Nermerteans	7
	Polychaetes	
	Lumbrinereis erecta	2
	L. minima	8
	Haploscoloplos elongata	2
	Prionospio near *malmgreni*	5
	P. near *kroyeri*	2
	Spiophanes missioniensis	2
	S. ?n. sp.	2
	Nerinides acuta	2
	Tharyx sp.	4
	Capitita ambiseta	67
	Crustaceans	
	Oxyurostylis pacifica	1
	Cancer jordani	1
	Molluscans	
	Tagelus californianus	1
	Solen rosaceus	2
	Chione undatella	1
	Larvicardium substriatum	2
	Macoma nasuta	3
	Tellina buttoni	1
	Saxidomus nuttalli	1
5	Turbellarian	1
	Polychaetes	
	Prionospio near *malmgreni*	3
	Polydora ligni	2
	P. socialis	1
	Capitella capitata	84
	Capitita ambiseta	6
	Holothurians	2
	Crustaceans	
	Corophium acherusicum	1
	Oxyurostylis pacifica	1
	Molluscans	
	Bullaria gouldiana	1
	Crepidula sp.	9
	Solen rosaceus	2
	Tellina buttoni	1

TABLE 5—Continued

Identification of Animals

Station number	Species present	Number of specimens
6	Turbellarian	1
	Nermerteans	9
	Polychaetes	
	Eteone dilatae	3
	Lumbrineris minima	2
	Haploscoloplos elongata	20
	Streblospio benedicti	18
	Prionospio near *malmgreni*	3
	P. near *kroyeri*	5
	Spiophanes missioniensis	6
	Nerinides acuta	3
	Tharyx sp.	15
	Cossura longicirrata	1
	Capitita ambiseta	181
	Amplurete ?n. sp.	4
	Amphicteis scaphlobranchiata	41
	Pista cristata	3
	Crustaceans	
	Caprellids	6
	Edotea sp.	1
	Oxyurostylis pacifica	3
	Molluscans	
	Tephtys sp.	2
	Tagelus californianus	11
	Laevicardium substriatum	4
	Chione undatella	1
	Macoma nasuta	1
	Tellina carpenteri	5
7	Nermerteans	2
	Polychaetes	
	Eteone dilatae	1
	Haploscoloplos elongata	3
	Streblospio benedicti	7
	Spiophanes missioniensis	1
	Prionospio near *malmgreni*	1
	Spiochaetopterus ?n. sp.	1
	Capitita ambiseta	63
	Crustaceans	
	Caprellids	3
	Molluscans	
	Tellina buttoni	2
	Macoma nasuta	2
8	Nermerteans	4
	Phoronid	1
	Polychaetes	
	Goniada littorea	1
	Streblospio benedicti	1
	Nerinides acuta	1
	Spiophanes missioniensis	3
	Capitita ambiseta	24
	Crustacean	
	Hemigrapsus oregonensis	1
	Molluscan	
	Chione fluctifraga	2
9	Nermerteans	3
	Polychaetes	
	Hypoeulalia bilineata	3
	Tharyx sp.	83
	Capitita ambiseta	1
	Molluscans	
	Chione fluctifraga	1
	Tagelus californianus	1

TABLE 5—Continued

Identification of Animals

Station number	Species present	Number of specimens
10	Nermerteans	7
	Polychaetes	
	Hypoeulalia bilineata	3
	Streblospio benedicti	63
	Boccardia redeki	1
	Tharyx sp.	115
	Capitita ambiseta	6
	Crustacean	
	Phoxocephalid	1
	Molluscan	
	Chione fluctifraga	1
11	Nermerteans	3
	Polychaetes	
	Eteone dilatae	3
	Lumbrineris minima	12
	L. erecta	3
	Haploscoplos elongata	10
	Streblospio benedicti	5
	Prionospio near *malmgreni*	4
	P. near *kroyeri*	1
	Nerinides acuta	7
	Spiophanes missioniensis	1
	Tharyx sp.	13
	Cossura longicirrata	7
	Armandia bioculata	3
	Capitita ambiseta	99
	Crustaceans	
	Caprellids	8
	Oxyurostylis pacifica	3
	Cirolanid	1
	Molluscans	
	Bullaria gouldiana	1
	Chione undatella	6
	Macoma nasuta	8
	Tagelus californianus	4
	Solen rosaceus	1
12	Phoronid	1
	Polychaetes	
	Eteone dilatae	1
	Lumbrineris minima	16
	Haploscoplos elongata	4
	Streblospio benedicti	8
	Spiophanes missioniensis	1
	Prionospio near *kroyeri*	1
	Magelona californica	2
	Spiochaetopterus ?n. sp.	1
	Tharyx sp.	4
	Cossura longicirrata	71
	Capitita ambiseta	12
	Ampharete ?n. sp.	1
	Pista alata	2
	Molluscan	
	Chione undatella	1
13	Nermertean	1
	Polychaetes	
	Eteone dilatae	3
	Nephtys caecoides	2
	Lumbrineris minima	10
	Haploscoplos elongata	4
	Nerinides acuta	1
	Streblospio benedicti	5

TABLE 5—Continued

Identification of Animals

Station number	Species present	Number of specimens
	Magelona californica	1
	Tharyx sp.	7
	Cossura longicirrata	1
	Capitita ambiseta	10
	Crustacean	
	Callianassa sp.	1
14	Polychaetes	
	Lumbrineris minima	1
	Haploscoloplos elongata	1
	Cossura longicirrata	8
15	Nermertean	1
	Polychaetes	
	Haploscoloplos elongata	2
	Tharyx sp.	1
	Cossura longicirrata	27
	Capitita ambiseta	5
16	Polychaetes	
	Nephtys caecoides	1
	Glycera americana	1
	Haploscoloplos elongata	3
	Streblospio benedicti	1
	Cossura longicirrata	36
	Crustaceans	
	Callianassa californiensis	2
	Shrimp	1
	Molluscans	
	Macoma nasuta	2
	Tagelus californianus	2
17	Polychaetes	
	Nephtys caecoides	1
	Lumbrineris minima	2
	Haploscoloplos elongata	8
	Spiophanes missioniensis	1
	Streblospio benedicti	6
	Prionospio near *kroyeri*	2
	P. pinnata	1
	Tharyx sp.	6
	Cossura longicirrata	1
	Capitita ambiseta	7
18	Nermertean	1
	Polychaetes	
	Lumbrineris minima	2
	Haploscoloplos elongata	2
	Prionospio near *kroyeri*	2
	Nerinides acuta	1
	Cossura longicirrata	29
	Crustacean	
	Callianassa californiensis	1
19	Polychaetes	
	Lumbrineris minima	5
	Haploscoloplos elongata	1
	Polydora ligni	1
	Tharyx sp.	3
	Cossura longicirrata	1
	Molluscan	
	Macoma nasuta	1

TABLE 5—Continued

Identification of Animals

Station number	Species present	Number of specimens
20	No sample taken	
21	Polychaetes	
	Lumbrineris minima	2
	Haploscoloplos elongata	7
	Streblospio benedicti	1
	Prionospio near *malmgreni*	2
	Cossura longicirrata	5
	Pista alata	1
22	Polychaetes	
	Eteone dilatae	1
	Hypoeulalia bilineata	1
	Neanthes succinea	12
	Streblospio benedicti	128
	Spiophanes missioniensis	13
	Cossura longicirrata	4
	Capitella capitata	29
	Molluscans	
	Tagelus californianus	3
	Bullaria gouldiana	2
23	Polychaetes	
	Eteone dilatae	1
	Neanthes succinea	3
	Lumbrineris erecta	5
	L. minima	11
	Haploscoloplos elongata	13
	Prionospio near *malmgreni*	1
	Pista alata	1
	Molluscans	
	Ostrea lurida	1
	Chione undatella	4
	Laevicardium substriatum	1
	Fishes	
	Clevelandia ios	2
24	Polychaetes	
	Eteone dilatae	3
	Lumbrineris minima	1
	Haploscoloplos elongata	2
	Prionospio near *malmgreni*	2
	P. pinnata	2
	Streblospio benedicti	1
	Tharyx sp.	1
	Cossura longicirrata	3
	Pista alata	1
	Molluscans	
	Tagelus californianus	1
25	Polychaetes	
	Eteone dilatae	1
	Neanthes succinea	3
	Lumbrineris erecta	1
	Haploscoloplos elongata	1
	Cossura longicirrata	1
26	Turbellarians	10
	Polychaetes	
	Eteone dilatae	13
	Hypoeulalia bilineata	22
	Neanthes succinea	17
	Dorvillea articulatus	1
	Haploscoloplos elongata	1
	Prionospio near *malmgreni*	2
	Nerinides acuta	15
	Streblospio benedicti	357
	Polydora ligni	126
	Capitella capitata	60

TABLE 5—Continued

Identification of Animals

Station number	Species present	Number of specimens
	Oligochaetes	
	Tubificids	67
	Crustaceans	
	Corophium acherusicum	397
	Caprellids	26
	Molluscans	
	Bullaria gouldiana	2
	Solen rosaceus	8
	Tagelus californianus	13
	Chione fluctifraga	2
	C. undatella	1
27	Polychaetes	
	Hypocuculia bilineata	1
	Neanthes succinea	11
	Polydora ligni	150
	P. nuchalis	4
	Streblospio benedicti	49
	Capitella capitata	10
	Oligochaetes	
	Tubificids	11
	Crustaceans	
	Corophium insidiosum	115
	Molluscans	
	Bullaria gouldiana	9
	Tagelus californianus	1
28	Polychaetes	
	Neanthes succinea	2
	Lumbrineris minima	1
	Nerinides acuta	2
	Streblospio benedicti	5
	Polydora ligni	2
	Oligochaetes	
	Tubificids	50
	Molluscans	
	Macoma nasuta	2
	Chione fluctifraga	1
29	Nermertean	1
	Polychaetes	
	Streblospio benedicti	5
	Capitella capitata	11
	Oligochaetes	
	Tubificids	26
30	Polychaetes	
	Neanthes succinea	2
	Streblospio benedicti	107
	Polydora ligni	1
	Boccardia redeki	1
	Cirriformia sp.	4
	Capitella capitata	16
	Oligochaetes	
	Tubificids	11
	Crustaceans	
	Corophium insidosum	4
	Hyale sp.	2
	Molluscans	
	Chione fluctifraga	4
	Tagelus californianus	1

TABLE 5—Continued
Identification of Animals

Station number	Species present	Number of specimens
31	Polychaetes	
	Neanthes succinea	3
	Crustacean	
	Hemigrapsus oregonensis	1
	Molluscans	
	Tagelus californianus	3
32	Sponge colony	--
	Polychaetes	
	Neanthes succinea	10
	Polydora ligni	63
	Streblospio benedicti	1
	Hydroides norvegica	2
	Crustaceans	
	Elasmopus rapax	9
	Molluscans	
	Ostrea lurida	3
	Tunicate colonies	--

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THE STATUS OF INTRODUCED WILD TURKEYS IN CALIFORNIA[1]

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The purpose of this survey was to determine the present status of wild turkeys in California. Information was sought to determine which planting sites have been successful and which have failed; the number of wild turkeys now living in the State; and the causes of success and failure of the plants.

Since 1928, 3,062 turkeys and 311 eggs have been distributed in a total of 118 separate plants. In 1951, only four of the planting sites have successful populations of birds. Ninety percent of the 1,410 to 1,665 wild turkeys estimated to occur in California are located on these four sites.

Future prospects for establishment of turkeys in California are best on the west slopes of the Sierra. Further plantings, if undertaken, should be of pure strain Merriam turkeys secured by taking wild trapped birds.

INTRODUCTION

Although wild turkeys (*Meleagris gallopavo*) are native in Arizona, New Mexico, and parts of Mexico, none of these game birds existed in California at the time of discovery and settlement. Since parts of California offer an environment similar in many respects to that found within the native range of the species, its absence from the Pacific fauna may be explained in part by the existence of desert areas which constituted an effective barrier to a westward extension of range.

In the belief that the distribution of the wild turkey was restricted by geographical barriers and not by a lack of suitable habitat in California, the State Division of Fish and Game began, in 1910, to experiment with introductions of turkeys in various parts of the State. Actually, the first known plant was made on Santa Cruz Island in 1877 by private ranchers (Gordon, 1950). This was at about the time that other exotic game bird species were being tested in California. The first introduction failed, and the next major attempt, by the State, apparently was initiated in 1910. From 1910 to 1912 a number of birds were released at various sites centered around Sequoia National Park (Ferguson, 1913). All of these releases were unsuccessful, although several showed promise for a number of years. About 1928, the Division of Fish and Game began its most extensive series of releases, in an effort to determine conclusively whether or not the wild turkey could become established in satisfactory numbers. This undertaking continued

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until 1951. A total of 3,062 turkeys were released and 311 eggs were distributed for hatching. Seventy-one different sites in 23 counties were thus stocked, in a total of 118 distinct releases. The locations of the release sites are depicted in Figure 1 and details are summarized in Table 1.

The birds used in these plants were, with one important exception, raised and released by the state game farms, principally those at Yountville and Los Serranos. Due to the extreme difficulty of raising birds of pure wild ancestry in captivity, the game farm stocks of turkeys were of hybrid origin, resulting from crosses between the domestic turkey and one or more of the wild subspecies. Apparently the latter were mainly the Mexican turkey (*Meleagris gallopavo gallopavo*) and the Merriam turkey (*M. g. merriami*) of the Southwest. In any event, all of the birds released, up to 1949, were actually semidomestic hy-

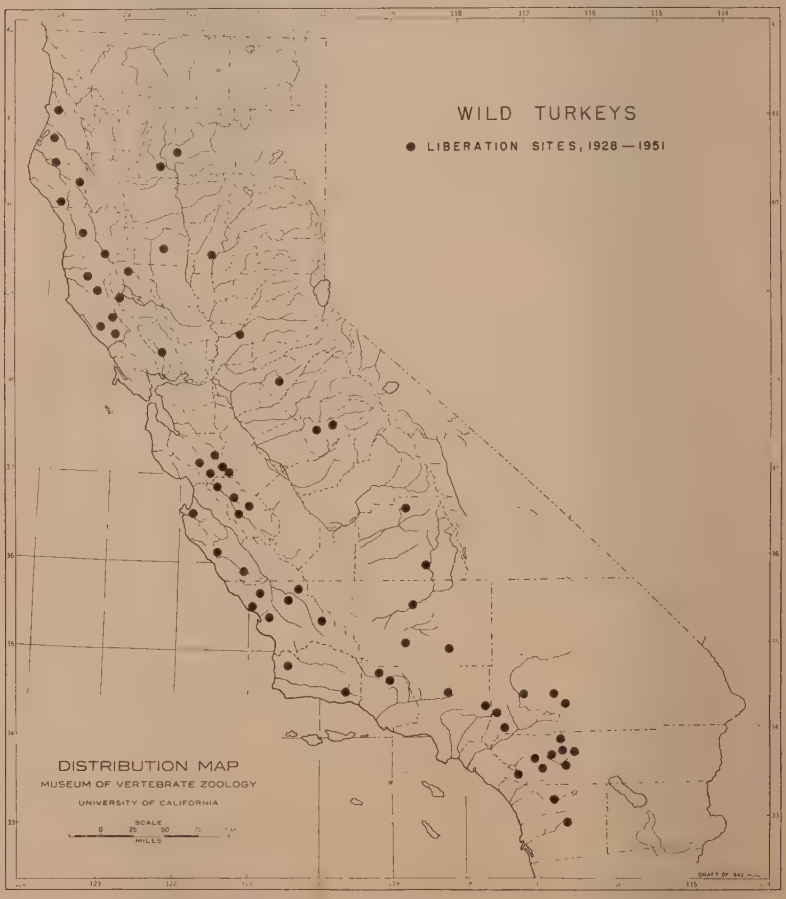

FIGURE 1. Distribution of the 71 sites where wild turkeys have been released in California since 1928.

brids. In 1949 and 1950 wild trapped birds from Arizona were imported and released on the west slope of the Sierra Nevada, giving rise to the only established population of truly wild turkeys in the State.

Since the beginning of turkey introductions, intermittent reports on the success of various local plants were submitted to the division offices. But no complete survey of the status of turkeys was attempted until 1946, when a wild turkey inventory of the State was compiled by David M. Selleck of the Bureau of Game Conservation and A. Starker Leopold of the University of California. This report concentrated upon the central coast counties, other areas being covered mainly by correspondence with Fish and Game wardens. The report was not published, but it is available in the files of the Department of Fish and Game (formerly the Division of Fish and Game), Sacramento.

The series of introductions which had begun in 1928 was terminated in 1951, pending information on the results of the various plants. In 1951, the writer, as a part of his graduate training at the University of California, undertook a survey of the status of California wild turkey introductions, with financial support from the Division of Fish and Game. The present report contains the pertinent results of that survey.

The purpose of the survey was primarily to discover which plants were surviving and which had failed, and to try to determine, in the case of survivals, the approximate number of birds present, their distribution, and their chances of success in the future. In addition, information was gathered regarding possible causes of failure among the unsuccessful plants, along with as much data as could be secured on general population trends, ecology, and habitat conditions.

METHODS

The first step consisted of gathering release records, previous reports, and any other material on the wild turkey in California which could be obtained. For the bulk of this material and for assistance and guidance during the course of the survey, the writer is indebted to Carl Van Ornum and David M. Selleck of the Department of Fish and Game, and especially to Dr. Leopold of the university.

After examining this material it was decided that the survey would best be directed toward an attempt to establish the present status of those plants which were still surviving at the time of the 1946 report by Selleck and Leopold, and of all plants made subsequent to that date. Any remaining time could be used in studying some of the unsuccessful introductions, in an attempt to reveal the cause or causes of their failure.

The actual survey was conducted during the summer of 1951. Three techniques were used: (1) Interviews with informed local residents; (2) correspondence with wardens, trappers, and ranchers; and (3) scouting trips in the field to secure first-hand information by observation. Although the last of these methods is in most cases the most reliable and valuable, time did not allow its intensive use in this survey.

The interview system was the one most widely employed. The accuracy of this method of surveying wild turkeys is attested by its previous use in Virginia (Mosby and Handley, 1943), Missouri (Dalke, Leopold,

and Spencer, 1946), and Alabama (Wheeler, 1948). In the Missouri investigation, 86 percent accuracy was estimated. The California survey differed in one important respect from these previous "interview surveys." In Virginia, Missouri, and elsewhere flocks of well-dispersed native birds had to be located as well as counted. In California, however, recently introduced and rather small and concentrated groups of turkeys were under study. The present survey could thus count upon fairly precise foreknowledge of flock locations by an examination of release records. It is believed that the advantage of such advance information compensated, at least in part, for the necessarily less thorough system of field checks used in the present study. The accuracy of the California survey should, thus, be nearly comparable to that of its antecedents.

In using the interview system, as many different opinions regarding the status of each local population were secured as possible. Local ranch owners and their riders were consulted, as well as Fish and Game wardens, trappers, game managers, sportsmen, and Forest Service employees.

In some cases, more intensive field work was both possible and necessary. The plants of wild-trapped Arizona birds in the Brush Creek area of Sequoia National Forest, Tulare County, were investigated in a week of field observations made with the assistance of A. J. Huhtala, local Fish and Game trapper. Thus personal acquaintance with the habitat and the distribution of turkeys at this successful site was obtained. The Brush Creek population is of particular interest since the habitat and the origin of these birds contrasts so strikingly with those planted in coastal areas.

Recurrent observations were made on a population occupying Castro Valley Ranch near Gilroy, Santa Clara County, between April and December, 1951. They were intended to serve as an intensive local study to supplement the more general state-wide survey. These data, however, are not reviewed here, but are being published separately.

SURVEY RESULTS

The results of the state-wide survey on wild turkey introductions are summarized in Table 1. A few general comments on some of the aspects of this table are in order before the results of the survey are discussed in detail. As may be seen, the plant sites are grouped by counties, in general working from north to south in the State. In most cases, sites are located by both the nearest town or post office and by the ranch or refuge where the birds were placed. In a few cases, however, the records are obscure and the exact sites unknown. In several instances the habitat type is missing. These represent areas which the writer was unable to visit and for which no habitat data were recorded.

In the column where the number of birds present in 1951 is estimated, a question mark has been used wherever any doubt exists as to the status of a given plant. Thus, where an unqualified "None" appears, it seems certain from all reports and observations that all birds have been lost. If "None" is qualified by a question mark, all reports indicate complete failure, but a slight possibility exists that some birds may still be present in the vicinity.

TABLE 1
Summary of Wild Turkey Introductions in California, 1928-1951

Nearest town	Exact locality	No. birds planted	Date of plant	Source of stock[1]	Habitat[2]	1951 Population	Comments
Humboldt County							
1. Eureka	Carson Ranch	20	Dec., 1928	Y	?	None(?)	Presumed a failure
2. Ferndale	Bognuda Ranch	26	Oct., 1931	Y	?	None	Little information available
		36	May, 1932	Y			
3. Benbow	Kinsey Ranch	25	Aug., 1932	Y	O,G	None	Tame, soon disappeared
4. Scotia	Larabee Ranch(?)	11	Nov., 1935	Y	?	None	Little information
5. Ft. Seward	Wallace Ranch	21	Dec., 1928	Y	O,G	None	Very tame; increased to several hundred, then disappeared rapidly.
6. ?	?	39	Nov., 1930	Y	?	?	Site unknown, presumed a failure.
Lake County							
7. Lakeport	?	36	May, 1932	Y	?	None(?)	Success unknown
8. Upper Lake	Van Ranch	21	May, 1932	Y	?	?	Flock reported 6-8 years ago on Snow Mtn.
Mendocino County							
9. Hearst	Henshaw Ranch	26	Dec., 1932	Y	O,Ch,P	?	24 seen in 1941 in Poison Rock area. None reported since then.
		49	Dec., 1933				
10. Laytonville	Wadleigh and Munn Ranches	30	Sept., 1931	Y	R	None(?)	No reports. Presumed failure
		20	Nov., 1932				
		6	Nov., 1934				
11. Ukiah	?	32	Aug., 1930	Y	?	None	No turkeys known in this area.
12. Willits	Willits Water Co. Ranch	28	Sept., 1931	Y	?	None	Very tame. Gone by 1939 or before.
Napa County							
13. St. Helena	?	25	April, 1932	Y	?	None(?)	Apparently unsuccessful.
Sonoma County							
14. Healdsburg	Briggs Ranch	20	Nov., 1928	Y	O,Ch	None	Water scarce. Last bird seen in 1943.
		4	Mar., 1932	Y			
15. Cloverdale	Elliott and Hollis Black Ranches	18	Jan., 1946	Y	O,G,P	130–160	See text.
		24	Oct., 1946	Y			
		24	Oct., 1946	Y			
16. Cloverdale	?	20	July, 1945	Y	?	?	Site unknown. Possibly as above.
17. Skaggs Spring	Hedgpeth Ranch	40	Dec., 1950	Y	O,G,P	30-40	See text.

TABLE 1—Continued

Summary of Wild Turkey Introductions in California, 1928-1951

Nearest town	Exact locality	No. birds planted	Date of plant	Source of stock[1]	Habitat[2]	1951 Population	Comments
Butte County							
18. Oroville	Near Oroville	17	Dec., 1930	Y	Ch,O	None	Water scarce.
Calaveras County							
19. ?	?	28	Sept., 1930	Y	?	None	Site unknown. No birds in county.
Glenn County							
20. Willows	Low Gap	20	April, 1932	Y	Ch,G	None(?)	Last birds seen at Brushy Ridge in 1940.
Mariposa County							
21. Mariposa	Just east	14	Aug., 1930	Y	O,G,Ch	None	Very tame. Gone by 1938.
22. Mariposa	O'Conner Ranch	12	May, 1931	LS	P,O	None	Soon disappeared.
Sacramento County							
23. Fair Oaks	?	18	May, 1932	Y	?	None(?)	
Shasta County							
24. Redding	10 miles N.E.	64	Sept., 1928	Y	O,Ch	None(?)	Very tame. Unverified report of movement to N.W.
25. Ydalpom	On Pit River	50	Oct., 1934	Y	O,Ch	None	Very tame. Soon disappeared.
Monterey County							
26. Jolon	Avila Ranch	24	Sept., 1932	Y	O,G,Ch	None(?)	Apparently failed. Birds from Adelaida plants are now in this area.
		5	Jan., 1933	Y			
		35	Sept., 1933				
27. Jolon	Hunter-Liggett Military Res.	56	Oct., 1944	Y	O,G,Ch	None(?)	Very tame. May have moved south but probably all lost.
		168	Dec., 1943	Y			
28. Big Sur	Post Ranch	25	Nov., 1949	Y	O,G,P,Ch	20-30	Fairly tame. Late rains hard on crop of young in 1951.
		35	Dec., 1950	Y			
29. Monterey	Rancho San Carlos	39	Dec., 1948	Y	O,G,Rip	8-10	Very tame. Success doubtful.

San Benito County							
30. Hollister	Merrill, Frandsen, McCreery Ranches	16	Nov., 1943	Y	Ch,P,O	None	Too arid and brushy.
31. Paicines	Peterson Ranch	8	Dec., 1948	Y	Ch,O,G	None	Too arid. Disturbed by pipeline construction crews.
32. Tres Pinos	Quien Sabe Ranch	24	Dec., 1946	Y	O,G	None	None seen for several years.
33. San Juan Bautista	Reeves Ranch	32	Oct., 1945	Y	O,G,Ch,P	25 30	Very tame. See text.
34. Hollister	O'Connell (Ward) Ranch	27	Oct., 1948	Y	O,G	None(?)	Fairly tame. Poaching.
Santa Clara County							
35. Gilroy Hot Springs	Brem Ranch	42	Oct., 1939	Y	O,G,Rip	None	Two females survived and moved onto O'Connell Ranch.
36a. Gilroy	Castro Valley Ranch	31	June, 1939	Y	O,G,R	250-300	See text.
		18	June, 1946	Y			
36b. Gilroy	?	26	?	Y	?	?	Site unknown.
37. Gilroy	Milias Ranch	36	Nov., 1947	Y	O,G	None(?)	Survived for a time. No recent reports.
38. Hollister	Frank O'Connell Ranch	16	Oct., 1944	Y	O,G	20–30	Built up to almost 200 and then fell off recently. See text.
San Luis Obispo County							
39. Adelaida	Bonheim Ranch	15	Sept., 1932	Y	O,G	660–750	See text. This is the largest and most widely dispersed population in the coastal counties.
	Turner Ranch	40	Oct., 1934		Rip		
		20	Oct., 1934				
		81	Nov., 1935				
		24	Oct., 1936				
	7X Ranch	19	Nov., 1937				
	Hardie Ranch	28	Nov., 1937				
		45	Sept., 1938				
		12	Oct., 1940				
		40	Nov., 1941				
	Allen Ranch	15	Oct., 1939				
		49	Oct., 1939				
		10	Oct., 1940				
	B. H. Davis	10	April, 1932				
		45	May, 1932				
40. Santa Marguerita	Arnold Ranch	44	Nov., 1947	Y	O,G	25-30	Dropped very low at first, now recovering.
		7	Mar., 1948	Y			
41. Cambria	?	34	Oct., 1934	Y	P,G	?	Little information available.
42. Cholame	R. E. Jacks Co.	12	Dec., 1932	Y	O,G,Ch	None	
43. Shandon	?	10	April, 1932	Y	O,G,Ch	None	No turkeys known in this area.
		36	May, 1932				
		18	May, 1932				
44. Simmler	Buckhorn Ranch	35	Nov., 1938	Y	O,G,Ch	None	Disappeared, cause unknown.

TABLE 1—Continued

Summary of Wild Turkey Introductions in California, 1928-1951

Nearest town	Exact locality	No. birds planted	Date of plant	Source of stock[1]	Habitat[2]	1951 Population	Comments
Kern County							
45. Isabel	Breckenridge Refuge	30	Nov., 1929	Y	P,Ch	10–20	12 birds, believed remnants of these plants, seen in 1950 on S. Fork of Kern River, between Isabel and Weldon.
		24	Dec., 1929	Y			
		32	Aug., 1930	Y			
		28	Aug., 1931	Y			
46 Bakersfield	?	32	Sept., 1942	Y	?	None(?)	Exact sites unknown. May have been as above.
		10	Mar., 1932	Y			
		18	May, 1932	Y			
47. Mojave	Dantley Ranch	40	Oct., 1946	Y	?	?	No information available.
48. Keene	Crofton Ranch	38	Dec., 1939	Y	?	?	No recent information. Last reports indicate a few still survive but are not increasing. Lumbering operations may be a factor.
	Bear Mountain	34	Jan., 1941	LS			
		50	Nov., 1941	Y			
		12	Feb., 1943	Y			
		24	Nov., 1944	Y			
		84	Oct., 1945	Y			
Tulare County							
49. Kernville	Brush Creek	11	April, 1949	WA	P,Rip	200(?)	See text.
		12	Feb., 1950	WA			
50. Badger	Waddle Ranch	14	Nov., 1939	Y	?	None(?)	No specific reports but no turkeys known in area.
Los Angeles County							
51. Big Pines	Big Pines Camp	40	Oct., 1930	LS	?	None(?)	General information indicates failure.
52. Brown's Flats	?	9	Mar., 1932	Y	?	None(?)	As 51.
53. ?	Weber's Camp	14	May, 1932	LS	?	None(?)	As above.
San Diego County							
54. Vista	Palomar Mtn.	80	April, 1931	LS	O,G,Ch	None	Very tame. Soon lost.
55. Santa Ysabel	Treanor Ranch	20	Nov., 1930	LS	O,P,Ch	None	Tame. Lacked water.
San Bernardino County							
56. Big Bear Lake	Burnt Flats	6	Mar., 1931	Y	O,P	None	Poaching apparently accounted for these.
		40	Oct., 1930	Y			
57. Big Meadows	Swarthout Ranch	26	Nov., 1930	Y	O,P,G	None	Lost to poachers and predators soon after release.
		44	Oct., 1931	Y			

58. Camp Baldy	Sansuaine Flats(?)	17	Oct., 1942	Y	O,Ch	None	Soon lost, cause unknown.
59. San Bernardino	Devil's Canyon	12	Dec., 1931	Y	Ch,P	None	Moved east, but soon lost.
60. Fontana	San Sevaine	34	Oct., 1947	LS	?	None(?)	Reports indicate shift in range, none seen in 2 years.
Santa Barbara County							
61. Santa Barbara	Mono Basin	24	Dec., 1940	LS	Ch,O,Rip	20 30	See text.
		8	Jan., 1941	LS			
62. Santa Maria	Rancho de Suey	30	Nov., 1947	LS	?	None(?)	Carcasses reported.
Riverside County							
63. Banning	Camp Comfort	17	Oct., 1944	LS	Ch,O,P	None(?)	Too arid probably. Moved a distance but gone now.
		31	Sept., 1946	LS			
64. San Jacinto	Garner-Bunker Ranch	24	April, 1931	LS	O,P,G	None	Fairly tame, but survived until area built up.
65. Hemet	Saunder's Meadow	25	April, 1930	LS	P,O,G	None	Tameness led to heavy poaching losses.
		29	April, 1930	LS			
66. Riverside	Nightingale Camp.	32	Oct., 1932	LS	Ch,O,P	None	Birds moved, probably due to aridity, but disappeared.
67. Pinyon Flats	Refuge 4D	17	April, 1932	LS	Ch,O,P	None	Tame
68. Hemet	Rawson Ranch	30	Sept., 1931	LS	Ch,O,P	None	Too arid(?)
69. Murietta	Vail Co. Ranch	30	Oct., 1947	LS	P,O,G	None	All vanished; reasons uncertain.
70. Idyllwild	Wellman Ranch	28	April, 1951	Y	P,O,G	25–35	Raised young in 1951. Habitat good but birds too tame.
Ventura County							
71. ?	Frazier Mtn.	37	Sept., 1931	LS	O,P	?	Last report indicates no sign for some time.
		41	Nov., 1932	LS			

Totals

Number plant sites	Number releases	Number birds released	Number birds believed present, 1951
71	118	3373 (3062 birds) (311 eggs)	1410–1665

[1] Y = Yountville State Game Farm; LS = Los Serranos State Game Farm; WA = wild trapped stock from Arizona.
[2] O = Oak; G = grassland; Ch = chaparral; Rip = riparian; P = pine; R = redwood.

In those cases where turkeys are known to have survived, a population total has been arrived at after compilation of all available data. This figure has been established, in most cases, after either personal observations or interviews, and represents the approximate number now believed present.

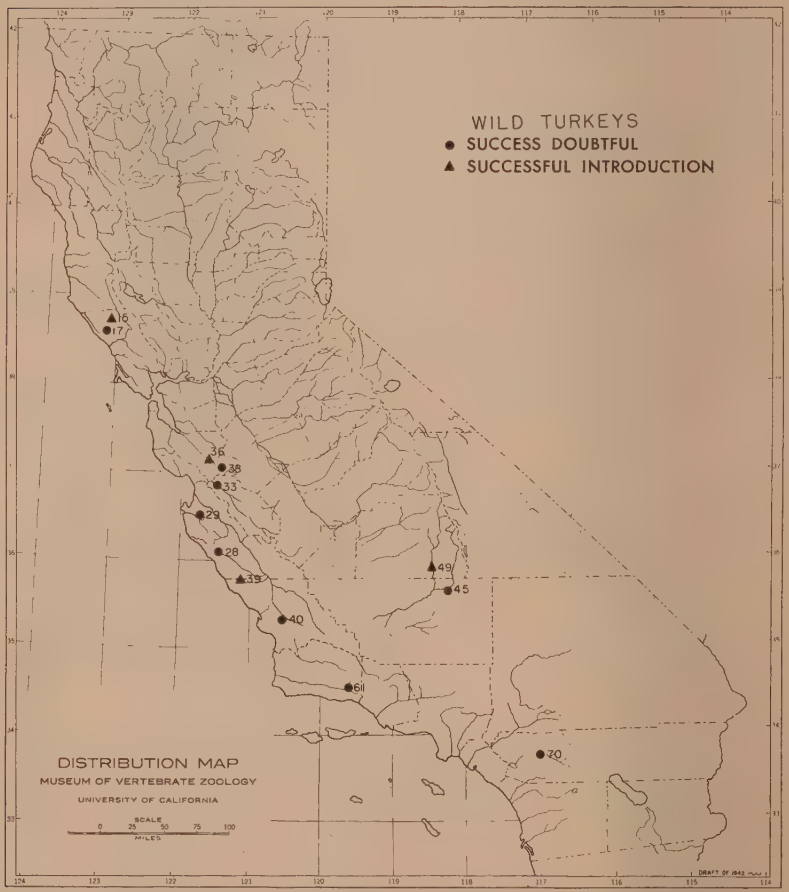

FIGURE 2. Locations of four wild turkey introductions judged "successful" in 1951, and nine introductions where turkeys still persist but where ultimate success is in doubt.

Successful Introductions

Introductions in this category are characterized by a marked increase in numbers of turkeys over the number released. They are termed "successful" only by comparison to other California plants which did not increase. Figure 2 indicates the location of the four successful plants, all of which are discussed below.

Cloverdale

Three releases, totaling 66 turkeys, were made a few miles southeast of Cloverdale, Sonoma County, in 1946. Warden Harley Groves and several local residents agree that approximately 150 birds are now present in this area. There are apparently two concentrations of from 50 to 60 birds each, with others scattered over a fairly wide area.

The tendency in the past and at present seems to be a movement of the main population toward the south and east from the original releases on the Elliott and Black ranches. The movement is into the hills and away from centers of human disturbance. This is a healthy sign, indicating a trend toward greater wildness in this population. The exact size of the area now occupied by these turkeys is unknown, but apparently small groups and single individuals are being seen at a considerable distance from the main concentrations, and dispersal seems to be well under way.

The main cover type now occupied by these birds consists of open oak stands interspersed with grassy clearings. Some pine is present, the amount varying locally. The main drainage is the nearby Russian River, and the year-round water supply apparently is adequate.

It is too early to predict the future of this population, but the outlook at present is promising.

Adelaida Area

The second of the successful introductions stems from a series of 13 plants of birds, varying in number from 10 to 81, and two lots of eggs given to local residents for hatching and later release. Total liberations amounted to 398 birds and 55 eggs. Turkeys were introduced at six points within the area, as indicated in Table 1, all sites being within a range of 20 to 30 miles west and northwest of Paso Robles, in an area centered around the Adelaida School District. All turkeys released were obtained from the Yountville game farm and were of hybrid semi-domestic stock of various strains. Introductions were made from 1932 through 1941.

Wild turkeys in the Adelaida district apparently did fairly well immediately after the first releases, but not until the Selleck-Leopold report in 1946 was any definite information secured. At the time of that study (15 years after the first release in the area), the population had increased considerably and had spread over a rather wide area in northwestern San Luis Obispo County. Selleck states that "Turkeys were located on the east slope from the Town Creek Ranch, seven miles northwest of Adelaida, to the Oakdale School, 3½ miles northwest of Templeton. On the west slope, from Mammoth Rock on Santa Rosa Creek to the Baldwin place on San Capajaro Creek about one-half mile from the Monterey County line." No estimate of total numbers was made in this report, but three concentrations of at least 100 birds each were mentioned, and many smaller flocks were thought to be present.

In the survey of 1951 the writer covered the central and eastern sections of this region and data on the northwestern flocks were obtained from Trapping Supervisor O. R. Shaw, who had kept careful records of these birds for a number of years.

Turkeys were located or reported on the west slope from the Baldwin ranch on the San Luis Obispo-Monterey County line south to Santa Rosa Creek, and on the east slope from a point about six miles southeast of Bryson to about three miles south of Templeton. The northern boundary of the population now apparently extends several miles north of Bryson and includes part of the Hunter-Liggett Military Reservation. The turkeys range over most of the region included within these boundaries, but there are definite areas of concentration. The approximate locations in 1951 of six of these concentration points are known. From northwest to southeast, they are as follows:

1. The Baldwin ranch—about 75 birds, estimated by O. R. Shaw.
2. The Hearst ranch—flocks totaling about 150 to 200 birds, reported by Shaw.
3. Along the North Fork of San Simeon Creek—about 150 turkeys, also reported by Shaw.
4. The Janesway (Hardie) ranch—about eight to ten miles northwest of Adelaida—reports indicate about 100 birds.
5. DeBost ranch (three to four miles west of Adelaida)—50 to 60 turkeys seen.
6. Willow Creek ranch (two miles southeast of Adelaida)—about 75 birds seen and reported.

The heaviest populations thus occur in the northwest corner and center of the area outlined previously. The turkeys range over a total area of approximately 332 square miles.

It seems probable, from all reports, that between 600 and 650 turkeys exist in the six concentration areas cited previously. In addition, small groups, varying in size from one to eleven birds, have been seen and reported to the writer by local residents. These small flocks and single individuals are scattered throughout the area between concentration points and their location and exact number are practically impossible to determine. After cross-checking all the reports, however, it appears that at least 60 birds were seen in 1951 which are not included in the concentration area populations. Obviously not all the turkeys in the area were seen or reported, since most of northern San Luis Obispo County is extremely rugged and seldom visited.

Therefore, a minimum of 660 birds have actually been seen and reported as present. The maximum of course, is difficult to determine and can only be fixed by an estimate based on the information available. It would seem that a conservative total figure would be about 750 turkeys in the entire area. This is the number given in Table 1.

The condition of the Adelaida introduction may thus be established rather well for 1951. At present, it is the most successful area in the state in terms of total population and amount of occupied range, and it has been self-maintaining for the longest period of time. Whether this range can be expanded naturally is questionable. On the west, and to the east, the limit of expansion is fixed by topography and intensive agriculture, respectively, and probably was reached in 1947 or before. Only in the north and south does adjoining suitable range seem to exist. There is evidence that some expansion is now taking place in both these directions.

The habitat of this region is fairly typical of the central coast ranges, although perhaps more rugged than the surrounding country. Upland cover varies from dense chaparral and oak stands to open live oak-grassland, with an interspersion of cultivated fields and pastures, particularly on the east slope. The canyon bottoms contain oaks and riparian trees and shrubs, including western sycamore and willows. In general the turkeys prefer the open oak stands and grassland borders and the edges of open fields, a choice typical of all the coastal sites.

Water is distributed in a rather irregular fashion over the district. The main sources are the permanent streams, especially Santa Rosa, San Simeon, and Town Creeks. A few springs and small artificial reservoirs are available to the birds on the east slope. The six areas of greatest population density are located around or along these various water supplies, indicating that water may well be an important factor governing the size of the population.

Castro Valley Ranch

A third successful introduction is centered at the Castro Valley Ranch, a few miles southeast of Gilroy in Santa Clara County. The author's studies in this area were made possible through the cooperation and generous assistance of Mr. Harold S. Chase, owner of the ranch, and his employees.

Forty-nine turkeys were released at the Castro Valley Ranch, 31 in 1939 and 18 in 1946. These birds were brought in as poults from the Yountville game farm and were raised in pens near ranch headquarters until old enough for release.

The turkeys did fairly well in this area from their first release, increasing rather rapidly and spreading farther to the west each year. The actual range occupied has fluctuated from year to year, and the present distribution is not as wide as was known at times in the past. In 1946, Selleck mentioned reports of birds from as far north and south as Hecker and Chittendon passes, respectively, and the writer has heard reports of turkeys seen several years ago in the vicinity of Mt. Madonna, on the Watsonville side of the range. At their peak of dispersion, these turkeys ranged over an area of about 14 square miles. By 1951, however, the range had been reduced to about six square miles, with the bulk of the population being concentrated on the Castro Valley Ranch proper. This range shrinkage occurred mainly in the west, very few birds now being reported on the Watsonville side of the mountains. In addition to the main population, a few turkeys are now reported each year on the Waugerman and Sargent ranches to the south, the Kelly ranch to the west, and the Whitehurst ranch near Hecker Pass on the north.

The main population on the ranch proper was censused by the writer. A complete census was attempted rather than an index or sample count. Careful notes were kept on all flocks seen, including the number of birds and the age and sex composition of the flock. The location of each group was designated on a map of the area. While the birds were neither banded nor marked by the observer, it was fairly easy to distinguish between flocks by use of composition data. On this basis, at least 180 different birds were observed during the summer and fall

FIGURE 3. A flock of wild turkeys on the Castro Valley Ranch, Santa Clara County, September 30, 1951. *Photograph by author.*

of 1951. In addition to the turkeys which actually were seen, signs of other small groups totaling about 30 birds were found on the Castro Valley Ranch. Finally, it was estimated that a minimum of about 40 birds occupied adjoining areas of other ranches. The total minimum population in 1951 was thus established at about 250 turkeys. The maximum probably does not exceed 300.

The principal upland cover consists of the coast live oak interspersed with grassland in varying proportions. Redwood-madrone stands occur commonly in the canyons and on the moister upland soils. At lower elevations typical riparian trees and shrubs are found along the stream beds. Chaparral occurs in scattered but dense stands. Several small streams have been artificially controlled by pipeline and by the creation of small lakes so as to furnish a year-round supply of fresh water over most of the area.

Adjoining localities differ to some extent in both cover types and water supplies, and these differences apparently have been an important factor in limiting the spread of the turkey population. To the east and southeast, the intensely farmed valley lands preclude range expansion. On the west and southwest, and in the north to some extent, few special provisions have been made to furnish summer water supplies. Furthermore, cover on the west side of the range in this district consists mainly of chaparral and grassland. The shortage of summer water and the absence of oaks and other favored woody species here is probably the main reason for the failure of the turkeys to maintain permanently more than a marginal population west of the ridge summit.

FIGURE 4. Oak woodland interspersed with grassland is preferred habitat for wild turkeys in the coast ranges. *Photograph taken September 30, 1951, on Castro Valley Ranch, Santa Clara County, by author.*

Brush Creek

The most recent of the four successful California turkey introductions is located in southern Tulare County, a few miles northeast of Kernville in the Sequoia National Forest.

This plant is of great significance since it represents the sole experiment in which turkeys of 100 percent wild stock were planted in this State. In contrast to the game farm hybrids released in other areas, the birds introduced at Brush Creek were wild Merriam turkeys (*Meleagris gallopavo merriami*), received from Arizona where they had been trapped on their native range. In all, 23 of these birds were released, 11 in 1949 and 12 in 1950. According to W. D. Stewart, who supervised the introductions, the birds were in excellent condition at the time of their liberation.

The author is indebted to A. J. Huhtala, fish and game trapper in this district, whose careful observations are the source of most of the available information on the plant.

In 1949, following their release in April, turkey sign was found in several areas, indicating a spread over about 16 square miles. No evidence of breeding was discovered the first summer. During the winter of 1949-50 sign was abundant on Lower Durrwood Creek where most of the birds apparently wintered. During the following summer (1950), turkeys were reported over a wide area, indicating a rapid dispersal. Following are some typical samples of such reports. On July 12th, a survey revealed turkey sign at Poloma, Bonita, and Boone Meadows and along Big Trout Creek. In August, Mr. Huhtala reported

three hens and 16 poults at Schaeffer Meadow, and in the same month the Forest Service recorded many turkeys along Big Trout Creek, including a flock of 23, mostly young of the year. On the basis of such observations, it appears that during the spring and summer of 1950 the turkeys dispersed over an area totaling about 126 square miles, an increase of over 100 square miles in their range. In addition, numerous observations of large numbers of young birds indicated a highly successful breeding season. In the fall of 1950, Mr. Huhtala estimated an increment in population to about 75 birds.

In 1951, dispersal continued, although apparently it was more limited in extent. All reports of new localities were limited to the southern edge of the range. The turkeys may well have spread farther in other directions but, if so, they have not been reported. Young birds also were seen frequently in 1951, indicating another good breeding season. In the fall of this year, at the completion of the present survey, Mr. Huhtala estimated an increase in population to approximately 200 turkeys. Since cattlemen and other observers report that the birds are now abundant, this figure may be conservative.

Although productivity has increased rather evenly each year, dispersal was by far the greatest in 1950. The rather explosive nature of the 1950 range expansion is a feature which is not clearly understood, since a more gradual extension might have been expected. Dispersal was more restricted in 1951, resulting in increased population density. Apparently the carrying capacity of the range occupied by 1951 was sufficient to absorb most of the population growth of that year. It is interesting to note that a correspondingly rapid increase occurred in a population of Merriam turkeys introduced in Wyoming in 1935 (Coughlin, 1943).

The Brush Creek plant is the youngest of the four successful introductions, yet is already second in area occupied and third in number of birds. What has enabled such success? The most obvious answer is the one main factor which distinguishes this plant from all others made in the State—the presence of birds from a pure wild stock. The evidence seems highly suggestive that the nature of the birds themselves is responsible for their remarkable success in this area. Predation is no lighter in this region than in most of the plant sites, and is probably heavier than in many. Human disturbance by grazing activities and sportsmen is present here, as in other areas. Plants of game farm birds have been attempted in the Sierra since 1910 and have all been failures. In short, all factors have been equal except the origin of the turkeys. The writer feels that this point cannot be overemphasized since it indicates not only a major factor in many of the failures in the past, but also points out a possible means of future success.

Lying between 3,000 and 10,000 feet in the southern Sierra, most of this region consists of dry upland soils with vegetational belts determined by altitude. Most of the upland cover falls within the ponderosa pine belt and stands of this and other pine species occur in varying density. Typical mountain meadows, scattered throughout the area, contain most of the green grasses and annual plants since few herbaceous species survive in the arid uplands. Around the edges of the meadows and along the several creeks are found willows, gooseberries, and other similar brushy species, as well as various lupines. At lower

elevations, in the deeper canyons and along the edges of the range, chaparral and various oaks predominate.

The feeding habits and foods of this population have not been determined, but since the Sierran habitat is similar in many details (excepting summer rains and grass crops) to the native Arizona environment from which the Merriam turkeys were derived, food sources and preferences are presumably similar. According to Ligon (1946), the main winter foods in Arizona are acorns, pinon nuts, and similar mast crops; in spring and early summer, insects and green plant material; in late summer, many types of seeds and berries, including manzanita and lupine. Most of the foods listed by Ligon for the Southwest are thus available from the same or similar plant sources on the west slope of the Sierra.

The beginning of the nesting season in this population compares closely to that given by Ligon for the same subspecies in Arizona and New Mexico, where egg-laying is stated as beginning about May 1st. Two life history features of the Brush Creek birds contrast sharply with those of the coastal plants. The nesting season of the turkeys now established along the coast begins in late March and early April, a full month earlier than in the Brush Creek population. The much later season in the latter may be accounted for by the late Sierran spring, a condition similar to that occurring in Arizona, to which climate the Brush Creek turkeys are native and thus adapted.

The second contrasting feature between coast and Brush Creek populations regards the seasonal movements of the latter birds. Because of the presence of low temperatures and heavy snow in their native mountainous country the Merriam turkeys migrate between definite summer and winter ranges. The turkeys of the Brush Creek plant show a similar migration, spending the summer along the stream beds and meadows of the upland region and moving to the brush, oaks, and canyon bottoms of lower elevations with the advent of winter. For the first two years after release, lower Durrwood Creek constituted the main wintering ground for these birds, as indicated by heavy signs found there from November to as late as April. Information received from Huhtala indicates that a second wintering ground is being established in the southern portion of the range, in similar terrain. Although the movements to the winter range in the Southwest sometimes involve great distances and consume a considerable amount of time, at Brush Creek the winter range, because of local topography, apparently may be reached by many birds simply by setting their wings and soaring from the ridge rim to the canyon floor. This close proximity of summer and winter ranges may be an important factor in the success of this population, since a shorter migration means less exposure to predation, poaching, and simply losing the way, all factors which take a toll of the Arizona birds according to Ligon.

Just how much territory is available for suitable winter range, which in this region lies mainly between 3,500 and 4,500 feet, is problematical. This aspect of habitat requirements deserves attention, however, since Ligon points out that, in Arizona, the main limiting factor for wild turkeys is the amount of food available in the wintering areas.

In general, the birds seem quite wild and are obviously becoming adapted to their new environment successfully. Future population

FIGURE 5. Winter range of the wild Merriam turkeys now established on the Sequoia National Forest, Tulare County. *Photograph taken near Big Meadow, August 7, 1951, by author.*

density is hard to predict but will probably continue to increase until reaching a stable level which may well be determined here, as in Arizona, by the carrying capacity of the winter range. The rapid increase and dispersal of this population is, without doubt, the most significant and promising event in the history of turkey introductions in the State. It should be remembered, of course, that this plant is only three years old and has not yet proven its ability to be self-maintaining over a long period. Other California plants have increased just as rapidly only to disappear. But none have been as wild or offered such grounds for optimism as the Brush Creek population.

Introductions Where Success is Still in Doubt

As Figure 2 indicates, nine releases, or 12.5 percent of the total number, fall into the category of doubtful success. These plants were so characterized since they possessed small numbers of birds which were still surviving but had not achieved any measure of success at the time of the survey. Such releases may be divided into two distinct groups, each of which is discussed briefly below.

Recent Plants. Three plants, at the Hedgpeth Ranch in Sonoma County, the Arnold Ranch, San Luis Obispo County, and the Wellman Ranch, Riverside County, were made within the last three years, and mainly because of their recent establishment cannot yet be termed either successful or failing. Table 1 gives the vital statistics for these areas, plus pertinent comments. The outlook is most favorable for the Hedgpeth plant which is located within 50 miles of Cloverdale. The

birds are quite wild and well protected and it is hoped that they may enjoy some of the success achieved by the Cloverdale population. The birds at the Wellman Ranch apparently are very tame and probably will disappear in time. The Arnold Ranch flock, increasing now after a poor beginning, shows some hopeful signs. On the whole, however, these three plants are too recent to justify predictions of their future.

Failing Populations. The remaining six areas where turkeys still exist in small numbers are a rather varied group but have one important feature in common. None has been able to build up and maintain a substantial population or show any evidence of being able to do so in the future. Pertinent information regarding these introductions is given in Table 1, the plants being listed as Nos. 28, 29, 33, 38, 45 and 61. The two Monterey County plants included here are of very recent origin but already show signs of failure. These introductions, together with those made at the Reeves and O'Connell ranches, display certain significant features which illustrate trends among unsuccessful plants and so will be discussed in the following section.

Time did not allow a personal check of the plant in Mono Basin, but information received from several sources indicates that while a small population still exists and reproduces each year, turkeys released there have been able to do little more than hold their own since their introduction in 1941.

In general, it seems that most of these nine releases are in a state of transition, the majority on the verge of complete failure, a few managing to hold their own.

Unsuccessful Introductions

Of the 71 sites where wild turkeys have been introduced in California since 1928, 44, or 62 percent, may be listed as failures. In addition to this number, reports indicate that all plants made before 1928 have also been unsuccessful. Table 1 summarizes the data obtainable from these sites. Areas designated as unsuccessful are either known to have lost all turkeys released or have failed to produce concrete evidence of the presence of birds for several years. In addition to the foregoing, most of the 14 plants where success is unknown also presumably fall into this category since no turkeys have been reported from their respective districts.

It seems pertinent to discuss some of the more general features of these failures.

Domestic Tendencies of the Turkeys

Among the many possible causes of failure in turkey introductions, the hybrid, domestic-wild origin of most of the birds used is one of the most frequently cited wherever such experiments have been attempted. The present survey shows this fact to be true in California as well. In about 20, or nearly half, of the unsuccessful introductions for which information is available, the tameness of the birds is commented upon, always unfavorably.

The inherent tameness of hybrid stocks is unavoidably strengthened by close contact with humans and artificial conditions on the game farm. As a result, many of the California releases were unwilling, even

if able, to adapt to natural wild conditions. In many cases such birds sought out the nearest farm yard or ranch after their release rather than dispersing into more rugged country. In some cases tameness was encouraged by ranchers who in a well-intentioned but misguided effort to aid the turkeys, left food for them in the ranch yards. In at least one instance, observed by the writer at the Reeves Ranch in San Benito County, the general habitat itself influenced this type of behavior on the part of released turkeys. Here water supplies and suitable cover are restricted, for most of the year, to a very small area around ranch headquarters. Birds in this area probably could not survive far from artificial food and water sources even if they originally had been wild enough to make the attempt.

What are the unfavorable consequences of such domestic tendencies and how may they determine the success of an introduction? For a thorough account of the differences between hybrid and true wild turkeys, the reader is referred to a study made by Leopold (1944). Many of the harmful effects of tameness are displayed by various of the unsuccessful California introductions, and it is of interest to note a few of them.

One of the primary difficulties lies in the fact that birds reared from hybrid stocks, under artificial game farm conditions, or brought in from similar sources in other states, may not be physiologically adapted to the environment in which they are released. At least one such case is known in California. In a letter quoted in an early article dealing with introduced game birds in California, Ferguson (1913), then acting superintendent of Sequoia National Park, states that in 1912 the first hatching season of turkeys planted in the park took place in February. Obviously, most of the young immediately died from the cold. Apparently from some Eastern or Mexican semidomestic stock, these turkeys were adapted to a much earlier nesting season than is possible in the Sierra of California, and could hardly be expected to survive.

Other effects of tameness, although of a less striking nature, are just as serious. For example, all reports indicate conclusively that predation is greatest where the turkeys are the tamest. Semidomestic birds evidently lack the instinctive wariness necessary to escape predators. This is especially true of hens and their broods. Losses of poults are severe in such populations. At the Reeves Ranch, where the birds are extremely tame, hens may lose their entire brood in a matter of weeks, or even days, after hatching. Even in relatively successful areas, such as the Castro Valley Ranch and the Adelaida district, brood losses are high. Only the Brush Creek birds compare, significantly enough, with native populations in size of surviving broods. Poaching is also facilitated, of course, when introduced birds are relatively tame.

Where the opportunity was available, several of the introduced flocks are said to have joined and mingled with farmyard poultry. Reports from the Wallace Ranch and from Willits, among others, indicate that many such birds were absorbed into domestic flocks and soon became indistinguishable. Besides the obvious loss of such individuals, a threat of epidemics exists where domestic flocks and "wild" releases are in close contact. Although no definite cases are known in California, reports from the East indicate that blackhead and other important

diseases may easily spread from farmyard poultry to wild turkey flocks, where contact exists either directly or through use of the same feeding areas (Mosby and Handley, 1943).

Tameness has thus been a definite limiting factor to success in many of the releases where semidomestic game farm birds were involved. Predation, poaching, and other factors, normally not critical in wilder populations, may become major decimating factors among releases of tamer birds. While some of the game farm hybrids may "go wild" and adapt to natural conditions rather successfully, as at Cloverdale, Adelaida, and Castro Valley, domestic tendencies still seem to limit productivity and dispersal. The only sure method of eliminating this factor, as has been demonstrated at the Brush Creek plant, is to use turkeys of unquestionable wild ancestry in all introductions.

Predation

It seems fairly certain that predation losses are often greatly exaggerated and are not as important as might at first be indicated. Predators known to take wild turkeys elsewhere, such as the coyote, bobcat, and golden eagle, and various small "nest robbers," exist in numbers in many of the areas where turkeys were introduced in California. It may be assumed that these species prey to some extent on the liberated birds. In certain sites, kills were actually witnessed and reported. One enemy of adult turkeys thus reported is the golden eagle.

While predation would not seem to be as severe as is usually rumored, the presence of numerous predatory species indicates that a number of birds must be lost, especially when young. Two facts, however, point out the secondary nature of these losses. First, there are as many or more predators in areas where turkey introductions have achieved success as there are in most regions where introductions have failed. Since the predators presumably are just as active in one district as in another, their kills cannot be the major factor determining success. Secondly, it was shown that losses of this nature are in direct proportion to the tameness of the turkey population involved. Generally, if the birds are wary and adaptable, losses are correspondingly light; if they show too many domestic tendencies, predators enjoy greater success. Finally, of course, if the habitat into which the turkeys are introduced supplies adequate cover (and if the birds are wild enough to take advantage of this cover), all other conditions being satisfactory, good productivity and population density may be expected regardless of predation.

The determination of success and failure is thus primarily dictated by the inherent nature of the introduced turkeys and the carrying capacity of the environment in which they are placed. Predation, in most cases, is simply one instrument of destruction for birds whose fate already has been determined by these basic factors.

Human Influences

The type of human disturbance most frequently reported during the course of this survey was poaching. Illegal kills were mentioned in survey records from 15 unsuccessful sites and were reported as being

heavy in 10 of these localities. One significant detail is always mentioned in reports from areas where such losses have occurred in any number. This is the fact that such populations are, or were, always characterized by their tameness and lack of caution. It is apparent from this that poaching and predation are similar in their action. In most cases, neither constitute the primary cause of failure or effectively limit the growth of a population, such failures or restrictions resulting from a population which is too tame to protect itself or located in a habitat where protection is impossible.

Other types of disturbance are less obvious, but may be locally significant in determining the success of turkey introductions. Such factors include the land use pattern found in the numerous localities where turkey range occurs on private lands. In most cases the principal use of the land is grazing. None of the reports gathered by the writer indicate that grazing or cultivation have figured prominently in any of the plant failures. More localized types of disturbance, such as construction work and lumbering operations, have been reported in a few of the unsuccessful plant sites, as indicated in Table 1.

Habitat

Since suitable habitat is one of the primary requisites of success, habitat deficiencies may well be responsible for the failure of a number of turkey introductions.

It has been mentioned previously that all three of the successful introductions along the coast occupy similar habitats, and the general features and cover types of such areas were described, a marked preference for live oak-grassland interspersions being noted. It cannot be assumed, however, that releases made in other habitat types have failed simply because of differences in cover.

Possible shortage of food during the dry period of late summer and early autumn may be a critical limiting factor in parts of the coast ranges. In winter, spring and early summer, green foods, ripening seeds of grasses and weeds, and insects adequately support the birds. In autumn, acorns and fruits such as manzanita, coffee-berry, etc., usually are obtainable. But the month of August and even early September may be barren of suitable forage for growing poults. During this time irrigated pasture or grain stubble may be required to sustain the birds. Lack of such supplementary seasonal food is a possible shortcoming of some ranges.

In other cases, inadequacy of available water supplies is indicated as having been important in determining success. This is especially true of the more southern counties (see Table 1). In Riverside and San Bernardino counties many of the unsuccessful plant sites are characterized by large areas of dense chaparral, and excessive dryness during the summer months.

Special habitat factors may have figured in the failure of a few introductions. Severe fires several years ago seem to have badly hurt plants made in the Jolon area of Monterey County.

But in general, the failure of the majority of the turkey releases in California is traceable to the poor stock used rather than to obvious shortcomings in protection or in habitat.

SUMMARY

Since 1928, 3062 turkeys and 311 eggs have been distributed in a total of 118 separate plants of wild turkeys in California. Of these plants, only four were found to be successful in 1951—those at Cloverdale, Adelaida, and the Castro Valley Ranch, and at Brush Creek. Ninety percent of the 1410-1665 wild turkeys now estimated as existing in California occur in these four areas. The Brush Creek plant is the most distinctive of the four, since it is the only one where wild-trapped birds were used and is the only successful plant located in the Sierra.

In the coastal areas live oak-grassland interspersions, provided with abundant permanent water, constitute the preferred habitat, and the critical season seems to be early fall, when critical factors limiting turkeys are food and water supplies. Although less evidence is available, winter food shortages may operate in a similar fashion for birds in the Sierra.

The large number of unsuccessful plants are thought to have failed primarily because of lack of inherent wildness in the stocks. Predation, poaching and other forms of loss are secondary factors, becoming critical only because of the tameness of the birds. Habitat deficiencies, particularly those concerning summer and fall water supplies, may account for a number of the failures in the southern part of the State.

The future prospects for the wild turkey in California look brightest in the Sierra where the wild Merriam turkey is becoming established. It is doubtful that the hybrid stocks established in the Coast Ranges, even the "successful" populations, are well enough adapted to spread and maintain sufficient densities to furnish hunting.

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MOUNTAIN LIONS IN CALIFORNIA[1]

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The purpose of this paper is to discuss the present status of mountain lions in California. Included are life history observations and a 44-year record of the kill. From 1907 to 1950, the State of California has paid bounties on 10,558 lions, an average of 240 per year.

The present population of lions in California is estimated at 600 adults. It is felt that this population is remaining steady or possibly gaining slightly.

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FIGURE 1. Head of an adult male mountain lion. *Drawn in 1951 by D. D. McLean.*

It is recommended that continued control of mountain lion numbers be maintained. Absolute extermination of the species is not advocated.

DESCRIPTION

There are two subspecies of mountain lions found in California: the California mountain lion (*Felis concolor californica*) and the Yuma mountain lion (*Felis concolor browni*). The adults in the flesh are from six to eight feet long from the tip of the nose to the end of the tail. The tail is from two to two and three-fourths feet long, and cylindrical in form with no enlarged tuft of hairs at the tip. The ears are evenly furred without tufts at the tips. There is no mane on the neck of either sex at any season of the year. No appreciable change in color in the pelage of the animal with the season is apparent nor is there much difference in density of pelage between winter and summer.

In the California mountain lion, there are two color phases, red, gray and intermediates between these two. In the red phase, the general color is ochraceous tawny. It is brightest on the top of the head and back, becomes lighter on the sides and pales to ashy white on the belly. The chin and throat are pure white. The tail is tawny on top, becomes grayish tawny on the under side, with the tip blackish brown. The outer sides of the ears are blackish brown from base to tip, while the inner sides are whitish. A black patch is located on the upper lip at the base of the vibrissae. The iris of the eye is yellowish with a greenish or bluish tint.

The gray phase of the California mountain lion is in general a dusky drab-gray which is darkest down the middle of the back and on top of the head. It becomes lighter down the sides. The blackish marking on the face and tail are the same as in the red phase.

The red phase, gray phase and intermediates each make up about one-third of the population in the California mountain lion according to Jay C. Bruce, retired state mountain lion hunter.

The Yuma mountain lion is a very pale animal to fit its desert habitat. The whole animal has a yellowish appearance. All of the dark markings of the face and tip of the tail are reduced in size and more diffused.

BREEDING PERIOD AND KITTENS

The gestation period of lions is 91 to 97 days. The average litter contains 2.4 young with 1 and 4 the extremes. It is interesting that occasionally embryos begin their growth only to cease development and then be resorbed. Mating may occur at any time of the year; however, the months of April and August are the most frequent kitten months.

The kittens at birth have the eyes closed and are about one foot long and average one pound in weight. The eyes open normally on the tenth day. The young travel with the female only, and normally are cared for by her until they are well over one year old.

Kittens are grayer brown than adults, and profusely spotted with blackish markings. They retain these spots until about eight months of age. The spots become larger and more diffused until they finally

disappear. Occasionally there are some indications of spots until the animal is almost a year old and weighs nearly 50 pounds. These remnant spots generally occur in the region of the shoulders.

The great size of the lion kitten's feet as compared with its body, or as compared with the feet of a bobcat, is worthy of note. No adult bobcat track that the author has seen would be as large as those made by lion kittens. Their feet are about two inches wide when their bodies are about house cat size. When the toes are spread and claws extended, the front paws are close to four inches across.

PRODUCTION

An adult female regularly ranged through four smaller basins at the head of Big Creek southeast of Groveland in Tuolumne County. On a number of occasions, over a period of seven years from 1915 to 1921 the tracks of this lion and her kittens were seen. The territory was good deer range, with about the right amount of brush, timber and narrow gullies for easy stalking. During the seven years, this female lion had two kittens in 1915, two in 1917, two in 1919 and three in 1921. There was no way to positively identify the animal as the same from year to year, but the fact that the extent of her range, as evidenced by tracks and kills, was about the same each year made it appear so. Here over a period of seven years, were produced a total of nine young lions, which, if they lived, would move out somewhere into other lion country. It is presumed that they moved into range left vacant by lions killed by man, or those ranges of lions that had died of old age or other causes.

MORTALITY

Dead lions are seldom found in the wild. The State Lion Hunter, Jay Bruce, found one old male that had been killed by another in a fight over a female. In 1932, the author found a male kitten about three months old in Vallecito Canyon on the southeastern slope of Garnet Peak in San Diego County. This kitten was at the base of a rock slide that could have been used by the female as a den. Apparently, it had been bitten through the skull by some large animal. The skull punctures were just in back of and below the ears on both sides. The holes were large and the skull bone was pushed in from both sides. It was not possible to say what had killed it, but it could have been done by the female accidentally when the kitten was pestering her, or when they were playing. It may have been done by a wandering old male, if they actually kill kittens, as has been reported by others.

Bert Higgins, former State Lion Hunter at Weaverville in Trinity County, found the skeleton of a lion near Trinity Center, in the early 1930's, that apparently had died of old age, as indicated by the teeth being almost completely worn off. Many reports of such finds may be based on skeletons of lions killed by hunters.

DISEASES AND PARASITES

Lions are relatively free of diseases and, except for some fleas, mites and ticks, are not pestered by too many external parasites. Ordinarilly, tapeworms and intestinal round worms are present, but are not often numerous.

One skin that had been sent in for bounty had what appeared to be a patch of scabies on the rump, another had a small patch on the middle of the back.

The author has seen small red mites at the corners of the eyes, in the creases on the outer edges of the ears and on the axial areas under the legs. Ticks are often fairly numerous around the head, neck and underparts.

RANGE

Normally, mountain lions are found in the Sierra Nevada between the 2,000 and 6,500 foot levels. They appear to prefer some brush and timber on rather rocky, rugged terrain. This cover serves to help them approach deer close enough for capture. They are at a disadvantage in the more open deer range of the Great Basin side of the mountains, and hence, are of less frequent occurrence in much of this region. Although not limited to range between the 2,000 and 6,500 foot levels, the bulk of the lion population is found there. Lions do cross the top of the Sierra Nevada, even as high as 11,500 feet, and have been found out on the plains of the central valley.

In the Coast Ranges, lions are to be found from sea level up to the tops of the highest peaks. Wherever deer are found in relatively large numbers, and the cover fits the lions' needs, we can expect lions to be present in some numbers.

FOOD HABITS

Although deer make up most of the diet of lions, they also prey upon other animals such as elk, bighorn sheep, cattle, goats, burros, colts, domestic sheep, antelope, porcupines, cub bears, domestic dogs and cats, hogs, turkeys, chickens, grouse, rabbits, marmots, squirrels, skunks, fish, bobcats and even mice. These are animals known positively to have been eaten by lions and probably killed by them, since lions are ordinarily not carrion feeders. It seems probable that most all of the animals roaming within the lion range are eaten on occasion. Insects are known to have been eaten by lion kittens and by one pet adult. It is possible that snakes and lizards are sometimes taken.

Some of the animals killed and eaten by lions, such as skunks and porcupines are probably taken when the lions are unusually hungry. Apparently porcupines are eaten more often than skunks, because a considerable number of the lions killed in porcupine country have quills in the forepaws, lips and face. One 115 pound male killed in Siskiyou County had at least 60 quills in evidence around his head and neck and about 15 in his left front paw. The author has observed several places where lions had apparently killed porcupines as evidenced by the tracks.

On November 8, 1916, in Mariposa County, the author's dog flushed an animal out of a manzanita thicket, from which emanated a strong skunk odor. The dog soon treed the animal, which proved to be a young lion. Upon approaching the dead cat, the odor of skunk was over-powering. Later when the animal was cleaned, the stomach was found practically filled with striped skunk meat, hide, hair and bones. An examination of the thicket revealed where the lion had killed and eaten the skunk. This lion was five feet two inches long and weighed 37½ pounds and still retained four or five dull diffused spots around the shoulders. It was probably about eight or nine months old. The animal was quite fat, showing it had been living well. There have been other reported instances of lions eating skunks, but in most instances, these lions were very old and thin, and probably were taking any prey that was available.

On the north end of Pilot Ridge, in Mariposa County, in 1920, 11 deer kills were found in one short canyon about three quarters of a mile long. The dates of kill were estimated from about six weeks for the oldest to about three days for the freshest. The canyon was literally covered with tracks of what appeared to be an old female lion and three kittens about six months old, judging from size of tracks. A local hunter, John McCauley, got two of the kittens, but the female and the other kitten moved out of the area.

Several different animals which had been horribly raked with long sharp claws have been seen by the author. Other than bear, the lion was the only predator in the area which was capable of inflicting this damage. One of these victims was a saddle mare in Tuolumne County which had been raked on both sides of the back from about one foot behind the shoulders all the way to the slope of the rump. She had apparently either bucked off her attacker, or brushed it off by running under limbs. Some of the claw cuts were almost an inch deep.

In 1917, the author shot and killed a four-point California mule deer buck only to discover that the top of the rump was badly clawed and torn. The claws had torn loose a flap of skin from the entire rump area and the upper rear half of the hams. The flap hung down like an apron in reverse over the hocks. This injury was quite fresh and showed the flesh on the rump to be badly mangled. It is doubtful if the buck could have survived this injury. Somehow the buck had dislodged the lion and gotten away. In 1930, near Glenville in Kern County, an adult domestic burro was seen that had been badly clawed on the side. The skin and flesh had recently been torn loose down almost to the ribs, but the wound had scarred over and was healing satisfactorily.

Lions are generally in good physical condition, showing they are able to secure food enough under almost all circumstances. When their teeth wear off or their claws are ruined, they may become thin and emaciated. One large one-eyed male that was killed in Trinity County was about as fat as any wild lion seen by the author. It appeared that the handicap of only one eye did not hinder his securing prey.

In another instance, a female with three of her front toes missing apparently had been having a difficult time securing food. She found a band of sheep in Tehama County and killed four, one of which she was eating when killed. She made no effort to run away when she was

approached by the man on horseback who killed her. A lion in this condition might conceivably attack a human.

Apparently lions give way to the brown bear when they meet on the trails. Two occasions were noted by the author where the cats had turned off the trail when meeting the larger animal, and returned to the trail after passing. There are many reports, however, of lions having killed bear cubs both in the wild and in zoos.

One case where a lion attacked an animal unsuccessfully was related to the author by Frank Herbeck of the Granite Springs District east of La Grange in Tuolumne County. Herbeck heard a commotion and upon investigation, found a durham bull standing dazedly under a digger pine and a lion about 40 yards away pulling himself along with his front legs. The old male lion had apparently jumped on the head and neck of the bull and tried to bite through the neck in back of the head. The bull was badly mangled on the face, one ear, neck, nose, and had lost the sight of one eye, but recovered. The lion was so seriously injured he was easily killed with rocks.

GENERAL HABITS

Of all the larger mammals found in California, the mountain lion is by far the least known. People living in lion country may go through an entire lifetime without as much as a fleeting glimpse of one of the big cats.

When it is remembered that an adult lion is six or seven feet long, stands taller than a police dog, and weighs from 110 to 165 pounds, we have to marvel at its ability to keep out of sight. It is true that a considerable part of their activity takes place at night, but lions do travel during the daylight hours part of the time.

On the other hand, when it is considered that a lion by taking advantage of the wind, small rocks, stumps, bushes, ditches and tree trunks is clever enough to stalk keen-sensed deer and make a kill, it is no wonder that man has trouble seeing them.

Many legends, myths and fancily colored stories abound regarding the mountain lion, cougar, panther, puma, catamount, painter or by whatever other local name the cat may be known. These stories grow over the years by repeated telling into fantastic yarns. The lion is a man-killer, a stock-killing demon, 9, 10 or 14 feet long according to some tales. Other stories show the lion to be a foolish, confiding big cat full of curiosity and playfulness. The truth lies between these two extremes. Lions will kill stock when deer become scarce. Occasionally, one starts killing domestic animals, finds that sheep, goats, calves and hogs are easy marks, and takes them almost exclusively. Lions rarely attack man unless provoked. Such attacks have occurred, but in the majority of cases, either rabies or other physiological troubles appear to have been the prime cause of the attack.

With all the pressure exerted upon it by humans, lions still persist over much of their original range. Only in those regions of the west where deer have been greatly reduced and forests and brush destroyed has the lion disappeared.

LION GAITS

The walking stride of a lion is about 22 inches for an adult. It is smooth and cat-like with the characteristic springiness of the family. The trot is also easy and gives the impression that the animal is flowing along. When running, the jumps are long and the big cat's body seems to elongate and contract more than in other animals of similar size. When pursued and hardpressed by dogs, the tail flops from side to side and at times is carried almost straight up.

Lions can run very fast for a short distance, but when pressed, they tire rather quickly, as do most cats. If allowed to lope along at their own pace, they are long winded. During a night's hunting, they often cover great distances with their long, easy striding walk. On horseback, the author followed fresh lion tracks in falling snow for about five hours and in that time, the lion had covered a distance close to 20 miles. The tracks appeared much fresher when first seen than they were when tracking was given up at the approach of darkness. Obviously, the lion was still hunting at that time. The route of this lion, which was persumed to be a male because of the size of the track as well as the markings left along his route, was about one quarter of an irregular circle. The trail meandered along the sides of a high ridge for about seven miles, and then turned off down a long spur ridge for about five miles, crossed a canyon to another series of ridges which were followed to their end. The lion swung back and forth from one side of the ridge tops to the other exactly as would a good deer hunter working the same country. In this manner, one basin head after another could be scanned. It was apparent that the deer along his route saw or smelled him, because in many places fresh tracks of running deer were seen. Most of the route was a little too open for easy stalking.

THE MOUNTAIN LION'S VOICE

Whether mountain lions scream or make other noises is still controversial. Some people contend that they scream or yowl, and others say they are silent. The author stood by the cage of a female in the San Diego Zoo and watched her while she uttered a yowl or scream. It sounded like any other cat, and was syllabized at the time as har-r-r-oo. It was not loud, but might, under proper conditions, be construed to sound like a distant human call for help. It sounded like the same call of a bobcat, was hardly any louder, but was about half an octave deeper.

The author cannot claim positively to have heard a lion call in the wild. Such calls as were heard could have been either lion or bobcat. A call similar to that heard in the zoo was heard four or five times in the canyon of the North Fork of the Merced River. In Cherry Valley, north of Hetch Hetchy, during the last week of June, 1923, the author heard a similar call a short distance from camp, across Cherry Creek. It was given several times. The following morning, in traveling toward Lake Eleanor in the direction from which the calls came during the night, the only fresh tracks observed on the well dusted trail was that of a very large mountain lion. On another occasion, while coming down a ridge of Hayfork Bally in Trinity County, the same type of call came from a narrow rugged canyon below. A call which many

people have probably heard in the woods, but never associated with the mountain lion, is a soft, almost bird-like, whistling mew that sounds like a wheezy "pu-u." The author heard this at least twice in boyhood, but did not connect it with lions until 1925. That year, in Yosemite Valley, this same call was heard several times, and upon investigation its source was found to be a male and female lion in the government cage. These animals were pacing back and forth along the side of the cage, pausing now and then to stare at the cliffs between Indian Creek and Yosemite Falls. Each time they paused to look they would give this low call and their lower jaw would tremble noticeably. They were looking high up on the valley wall. Although the author was not able to discern any living thing on the rocky benches, it was surmised they had seen another lion moving along one of these shelves. Both animals were restless and disturbed for about an hour.

Since then, the author has heard recently captured kittens give this call. Once near Willow Creek, on the Redding-Arcata highway, two animals were heard answering each other above the highway to the north of the creek.

The growl of a mountain lion is deep and menacing. However, when treed and growling at a human, they are not nearly as dangerous as a bobcat. Lions "spit," of course, like any other cat, except that it is very loud and often explosive. Even kittens "explode" when suddenly touched or startled as do domestic kittens, but normally give only a soft hiss.

Two young lions when playing roughly will growl and occasionally mew when one claws the ear of the other enough to hurt. On the whole they are much like the adults in their extreme silence as compared with other members of the cat family.

ODD BEHAVIOR

Lions on occasion do unexpected things, such as standing or lying on an open side hill while watching humans working below or across from them, or even strolling nonchalantly through camps and even towns without any evident fear. Whether these apparent lapses are due to curiosity or simply a lack of fear is a question. It may be that the lion is not particularly afraid of man, but because of its natural, inherent stealth gives the impression of fear.

Occasionally lions are found entirely out of normal range and even out of deer territory. Two adult lions were killed several days apart in a culvert between Merced and Snelling in the middle of the San Joaquin Valley in Central California. Another lion was killed near the city limits of San Jose in the flat agricultural Santa Clara Valley. One lion was killed in 1948 on the Antioch Bridge across the San Joaquin River, many miles from its normal range.

That lions on occasions may have little fear of men is shown by an experience in Yosemite National Park, in 1926. The night after the opening of the all-year highway into Yosemite, the author was stationed as night relief at the Alder Creek checking station on the Wawona Road. In the dim light while watching about 15 deer at some salt blocks near the station, they were observed suddenly to break and run; some of them snorting loudly. It was suspected there was probably a lion around.

Several times during the night, deer were heard rushing away from the salt rocks and snorting. Along toward daylight, the author lay down to rest on a cot in the island of the divided road. Upon getting up, just after daylight, an extremely large lion track was seen along the outer edge of the road about seven feet from the cot. The track came down automobile wheel tracks without a waver as it passed the cot to a point about 50 feet beyond. There the lion had crouched on its stomach at the outer edge of the road, apparently to watch down the gully below the road. Upon looking about, it was found that a smaller lion had gone past the cot on the opposite side headed the other way. It was obvious they had paid little attention to the author lying fully clothed on a cot in the open between the divided roads.

At that time, state lion hunters could still hunt lions in national parks under permit, so a State Lion Hunter, Jay Bruce, was called and arrived about 4 p.m. that afternoon. Within a half hour after his arrival, five lions—a 153-pound male, 110-pound female and three yearling young had been killed, all within a mile of the station.

HABITUAL BEATS

Lions, for the most part, are creatures of habit, as is evidenced by their rather strict adherence to beats or circuits. Old males may have a circuit of 75 to 125 miles, but often no part of the beat will extend more than nine or ten miles from the center of the lion's range. Ordinarily a male's circuit follows a rather definite route along ridges and through passes that lead from one good deer range to another. It generally intersects as many female lion ranges as possible.

The frequency of round trips on a male lion's circuit varies in elapsed time with his hunting success en route and with his contact with females along the way at breeding time. In general, a circuit is completed in less than 10 days, and the average is probably about five.

A female's circuit is nearly always much shorter and more restricted than the male's, particularly so when the young are too small to travel long distances. Female lions ordinarily travel in canyons more than do the old males. Consequently, their tracks are more apt to be seen by fishermen and people traveling streamside trails and roads. Deer hunters and horsemen are more likely to encounter the tracks and signs of the old males on the higher ridges.

One big old male lion in Trinity County regularly made a deer kill about every three weeks in the steep narrow canyon of Packer's Creek, north of Hayfork. His circuit was a large one, extending eastward to Mike's Peak, Gunsight Peak and along the Yolla Bolly crest southwestward to the ridge between the east fork of Hayfork and Brown's Creek, thence across the Douglas City-Hayfork road and up to the slopes of Hayfork Bally. This animal apparently remained in this area about five years before he was killed by a local hunter in 1934. On occasion, his route varied a little but, on the whole, followed the same general pattern.

Another large male had a very interesting circuit from the Big Bend country of the Pit River along the eastern slope of Hatchet Mountain into the Burney Butte-Thousand Lakes Basin area, thence westward

to the slopes above Battle Creek and north along the western side of Hatchet Mountain to the Big Bend country again.

Female lion circuits are much harder to trace, because they work more in the canyons where rock and trash make visual tracking more difficult. In fact, the author cannot say positively that females have definite routes, since their tracks may appear anywhere within their range.

One female with two kittens, estimated to be about five months old when the tracks were first noted, worked Grouse Creek and the basins of Indian Creek and Avalanche Creek in Yosemite National Park in 1926. Her tracks could be found with those of the kittens from the top of the falls, where Grouse Creek drops over the rim into the Merced River Canyon, upstream across the Wawona Road to the Chinquapin-Glacier Point Road and also in Indian Creek and Avalanche Creek basins up to about the same level. Her tracks were seen on a number of occasions along the Wawona Road and at several different places along the three creeks. Generally all three tracks were together, but in some instances the female was alone. On a trip down Indian Creek, her tracks were seen coming up the hill. Down the trail about a half mile, there appeared numerous tracks of the young. Upon search, a deer kill about 48 hours old was found. Apparently, the lion had killed a velvet-antlered three-point buck, and after taking a meal or so, left the kittens, and went off on a scouting expedition in search of another deer. The female was probably flushed off the trail by the author as later were the kittens from their meal, but none of the three was seen.

LION SIGN AND MARKINGS

The markings left by lions are obvious to people who are familiar with them. To the uninitiated, such signs are passed by as the digging of squirrels or other rodents. Three types of marks are made. The one most often seen is made by the two front paws of the lion. In making it, the paws are placed together upon leaves, pine needles or litter well out in front of the animal. The toes are then flexed and drawn down while the legs are being drawn toward the chest. This pulls the trash and dirt toward the animal and piles it along the near edge of the small pit caused by the toes and claws digging into the ground. The pits made by an adult male are generally about one foot wide and 10 to 12 inches long and vary in depth with the hardness of the trash and ground.

Another type of marking is much rarer. It consists of a heavily scratched series of marks made by long strokes. A considerable amount of litter and surface cover is torn up. The significance of the two markings, or the difference in the meaning of each, is not known. The former is commonly seen while the latter is very unusual. The author has seen the latter markings on only three occasions, once on the ridge between the Clavey River and the head of Jawbone Creek in Tuolumne County, and twice on Volcan Mountain in northeastern San Diego County.

Lions appear to choose certain types of places for markings. Apparently most of the male lions passing these sites leave their marks. Passes, benches, narrow canyon bottoms and narrow places on the tops

of ridges are the commonest spots. There is no evidence that females ever leave any type of marks.

Another type of lion sign that nearly always goes unnoticed by the average person is the scratching log or stump where lions sharpen their claws as do domestic cats on fence posts or small trees. Several logs have been seen that were deeply gouged from long years of scratching or claw sharpening. One such log lies in the narrow bottom of Grizzly Canyon southeast of Mt. Hamilton in the headwaters basin of Coyote Creek in Santa Clara County. This old digger pine log lies across the bottom of the narrow gully. When last seen in 1946, it had been clawed to a depth of about one and one-half inches.

If a male lion is killed and another moves into his range, the same marking stations and routes are generally used by the new animal.

In spite of their size, lion tracks are not very obvious to the average person. The ordinary hiker or person traveling through lion country does not look at the trail or roadway over which he is traveling or attempt to evaluate what he does see. Animal tracks along mountain trails and roads many times tell a story of great importance to the animals that made them, sometimes even the drama of life and death.

STALKING PREY

The lion's prey is captured and killed, under ordinary circumstances, by a skillful stalk to a striking distance of from 20 to 75 feet. At this distance, the lion usually waits until the victim is off his guard. Then, in a sudden bewildering bounding rush, it strikes the prey, bowling it over and killing either by a bite through the back of the neck at the base of the skull or by disemboweling it. As to which is the commonest method of killing, there is some disagreement. It appears to vary with the individual lion and also with the position of the prey in relation to the point of attack.

At Pigeon Flat on the western slope of Pilot Peak Ridge in Mariposa County, ground signs revealed where a fairly large lion had crawled on its belly for about 200 yards in stalking a lone doe that had apparently been browsing on a small hedged buck-brush shrub (*Ceanothus cuneatus*). The last rock behind which the lion had crawled was not much larger than a sombrero hat, but the animal had crawled about 30 feet from a small ditch with this single rock as the only cover. The remaining distance of about 75 feet across an open flat, was made in three and one-half bounds. The doe was hit at the time the lion had gone a little past the middle of its fourth leap. The doe made only one jump of about 10 feet and was struck down just as she started her second jump. Sign in the light fall of snow showed there had been little or no struggle. The lion had killed the doe with a bite through the neck about five inches back of the base of the skull. It had then partially carried the doe about 60 feet to the edge of a clearing near a small live oak tree where it had eaten nearly half of one loin, all of the liver and a portion of the rear half of one ham. It had covered the carcass partially with leaves and trash, and then gone up the hillside about 75 yards and bedded down under the end of an old yellow pine log lying on the slope. The author apparently interrupted the lion's siesta about 1 p.m., because very fresh tracks were found leading from the bed into dense brush. The kill apparently had been made in the

forenoon, because the body of the doe still had considerable body warmth. The marvel was how the lion had been able to stalk a deer in such an open situation in broad daylight.

DOMESTICATION

In December, 1914, a large old female was killed on the Stanislaus River north of Sonora. Its den, a broken-down log cabin, was found by W. C. Johnson to contain three kittens about the size of house cats. The kittens were taken alive, but were "pretty brambly" and full of fight. Although quite young when captured, about three months passed before they appeared tame. One of these animals lived about 11 years, but the other two died of some nutritional ailment when about five years old.

In cases where kittens are gotten before their eyes open or a few days thereafter, they tame very quickly and ordinarily show no fear or viciousness.

The dispositions of kittens are variable, some are docile and become very gentle, whereas others from the same litter will strike with their forepaws, spit and growl every time they are approached. This difference is evident even in quite tiny kittens. Their individual temperaments seem to remain unchanged regardless of how long they are kept, or the amount of attention they are given.

A 30-pound kitten which was captured alive in Glenn County spit, growled and yowled the whole time it was being brought out of the mountains. This animal did not live more than three weeks after capture, as it practically refused to eat and continually tried to get out of its large cage.

Other lions, even when fully adult, have adjusted themselves to captivity and lived a fairly long life.

One very large old tom, which had been captured as a kitten and tamed, was always very gentle and reminded one of an old pet house cat. This lion was allowed to roam around the owner's ranch. Whenever anyone started to pet or scratch him, he would flop down on his side, shut his eyes and start purring. His great claws would extend and retract just as those of a house cat under the same circumstances. He preferred to be scratched under the chin, around the ears and under the throat.

As soon as one stopped petting the animal and started to walk away, he would get up and follow until he got a chance to rub against the side of the person's legs with his neck and shoulders. This was almost enough to knock a person down. He habitually rubbed against people in efforts to get someone to scratch or pet him. He was always fat and looked well fed, but, so far as known, he never killed anything larger than mice and grasshoppers. This tame lion was always very quiet. No one ever heard him scream or yowl. He did give the whistled mew characteristic of lions, and often growled when roughing in play with dogs. His favorite pastime, when not playing with the dogs and people or sleeping, which he did by the hour in the daytime, was stalking grasshoppers and swatting them with one of his great forepaws. He hunted lizards in the rocks and around the ranch, but the author never saw him catch one. The owners reported that the animal prowled around the area at night, probably hunting for mice and wood rats.

This lion was notable for his thorough domestication and good disposition. His playfulness and comical stiff-legged, high-tailed, high jumps when playing with the dogs was always astounding to anyone seeing this the first time. He had been trained not to jump on people in his play, as some pet lions are wont to do. He died when 14 years old.

A female three-year-old, in Arizona, on a ranch which kept chickens, goats and cattle, was allowed to roam free and never bothered any of the domestic animals. A yearling on a ranch near Fallon, Nevada, in 1923, could not be trusted around the chickens, and had killed a number of them and two house cats before it was sold. It appears that domestic lions in this respect are no different from domestic cats which at times will start killing other animals around the house in the same way.

There are several shortcomings to lions as pets. Their great size when fully grown and the consequent amount of food they require should be considered. They often startle visitors. They can be extremely rough when playing. Even a kitten, in play, can give a human some bad scratches just in fun. To prevent this the claws can be clipped at the roots. A 160-pound lion in play may pounce on a man, knock him flat, and then sit on him, licking his face or hair with its heavily barbed tongue. What is play to the lion can be hard on human anatomy.

LIONS FOLLOW HUMANS

During the late summer of 1918, the author had been fishing on the North Fork of the Merced River below Bower Cave, and walked home after dark. Early the following morning when going back down the same road traveled the night before, it was found that a large lion had followed my trail for about two miles. At several places where the fish catch had dripped into the dust of the road, the lion had sniffed, and apparently licked the spots. Whether this lion was very hungry or the fish odor stirred up his cat instincts, there is no way of knowing. Whether it followed behind or came along much later at night is not known.

Another instance of a lion following a person was related to the author by a prospector on the North Fork of the Trinity River above Helena, in 1933. He was walking back to his cabin from his mine. He had walked about one-half mile when he realized he had forgotten his lunch pail. He started back to get it and, upon rounding the first curve in the trail, he saw a lion coming along sniffing at his tracks. He stood still and the lion came within about 75 feet before it saw him. It stopped, gazed at him for a few moments, and then turned off the trail and walked slowly into the brush. He believed that the lion had come into the trail, started walking along, and was sniffing at his tracks out of curiosity. At any rate, the man went on to pick up his lunch pail, and on coming back up found the lion had returned to the trail about 200 yards beyond where they had met. The lion had continued to within sight of the miner's cabin, where it had turned off up the hill.

LION HUNTING

Lion hunting in California, or any other place, is hard work. It has to be done mostly on foot over extremely rugged terrain. Often the chase takes the hunter across mountains and canyons as well as through miles of brush and rocks. Many times the kill is made a long distance from the hunter's car or horse.

In order to keep within hearing of the dogs, it is often necessary to run downhill and on the level stretches and to walk as fast as possible on the upgrades. Such a pace is extremely fatiguing for anyone. The kind of life necessary to lion hunting involves camping out in all sorts of weather. Very often meals are missed. Occasionally, the hunter is caught too far from camp to return before nightfall, so must spend the night in the open. When this occurs in bad weather, it may involve considerable hardship.

It takes a certain type of man to make a good lion hunter. He must have a rugged constitution with great stamina, a thorough knowledge of the out-of-doors and an unerring sense of direction. Above all, he must be able to interpret the sign he sees on the trails, both of lion and of other animals. In other words, he must be able to think like a lion. This ability can often save him a great amount of walking in that he can determine from old lion tracks their general beats through an area, and go to some distant ridge or pass to intercept the lion trail where the tracks are more fresh.

While an amateur lion hunter often kills a female lion and goes on his way, the professional will continue to search the area, often for several days, in order to secure any young that may have accompanied the female. Also, the professional notes the mammary glands of the females. If there are signs of young having recently suckled, he will immediately start his dogs to search out the location of the den where the young have been left. Sometimes small young are very hard to find, because they apparently leave so very little scent. Usually the female has left so many tracks in the immediate vicinity of the den that the dogs have a difficult time centering the den's location. The hunter must help the dogs under these circumstances, and through his knowledge of logical places can often find them where the dogs would fail.

LION KILL DATA FROM BOUNTY RECORDS

From October 1, 1907, to the end of December, 1950, there had been 10,558 mountain lions turned in for bounty at the Department of Fish and Game offices.

From 1907 until June 30, 1917, a bounty of $20 per lion was paid regardless of sex. From July 1, 1917, to September 14, 1945, the bounty was $20 for a male lion and $30 for a female. Since September 15, 1945, it has been $50 for males and $60 for females. The total kill bountied since the larger bounty for females has been in effect was made up of 3,829 males (48.4 percent) and 4,082 females (51.6 percent). For the first five years (1917-1921) the males outnumbered the females. During the next 21 years (1922-1942) the females outnumbered the males in all years except 1923 and 1937. During the last eight years

(1943 to 1950) males in the catch equaled or led females in five of the eight years and were only one less than females in 1945. The male kill has actually led the female kill in 10 of the 34 years (1917-1950) with one year (1943) exactly equal, and several years showing a difference of only two or three.

Noticeable fluctuations in the lion kill of various counties will be found in Table 1. There may be several reasons for such fluctuations. When a state lion hunter moves into a county that has been lightly hunted for some time, the kill in that county will ordinarily increase, sometimes to several times the yearly average. Immediately following a big burn, the lion kill generally drops because of the opening of the country and the dispersal of the deer. As the burn grows up and the deer begin to concentrate on the area of succulent forage, the lion population will usually increase. Fluctuation in the lion kill also occurs within the year. There is a low in midwinter and early spring and an abrupt rise in the fall. This is due to hunting pressure, which increases greatly during the deer season with thousands of hunters with rifles and some dogs in the field at that time. In winter, only hunters actually hunting lions are apt to bag them.

Outbreaks of deer disease, of course, will force a shift in a lion population because of food scarcity. It is probable that lions in areas of heavy deer mortality become hard pressed to secure enough food to keep them alive. Several lions killed in Mendocino County during the period of heavy deer loss of the late thirties were in very poor condition. It is probable at such times they will turn to whatever food is available, whether mice, rabbits, sheep, goats, calves, colts or hogs.

The presence of man in large numbers does not seem to cause shifts in lion populations, so long as good cover and a sufficient population of deer are available. This was evident during the depression years of the 1930's when great numbers of people turned to mining along the Mother Lode in the Sierra Nevada, and in the Trinity-Shasta area. The mountain lion kill in these areas did not decrease, but actually increased over most of this territory. Apparently miners hunted them to some extent in order to augment their meager earning from gold.

It is evident that during periods of high wages and good economic conditions the hunting pressure on lions lessens. The hard labor necessary to secure a lion probably discourages hunters in periods of easy money. Even the hunters who hunt lions more or less for fun often turn to other occupations during such periods.

In some areas such as western Humboldt and western Mendocino Counties the lion population was reduced soon after the start of bounty payments and has never increased much since. The population in Sonoma County has fallen to a sustained low as shown in Table 2. The lion kill in Siskiyou County has fluctuated over the years as can be seen in Table 3. Table 4 shows a leveled-off take of lions in Humboldt County. Trinity County has been the most consistent of the counties with a large kill, as shown in Table 5.

At the present rate of kill, Trinity County could overtake the lead from Humboldt County within the next three or four years.

It is of particular interest that some counties maintain an almost continuous kill of lions even though they may be low in actual numbers killed. As may be seen in Table 1, such counties are Butte, with a total

of 78 lions killed, having had at least one lion per year for all but 13 years; Colusa with 86 killed and only 14 years with none; Madera with 106 killed and only nine years with none; Riverside with 108 killed and only 10 years with none; San Benito with 68 killed and 13 years with

TABLE 1

Record of Mountain Lion Bounties Paid by Division of Fish and Game

County	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
Alameda		1				1											1			
Alpine									1									1	1	
Amador		3		1	2	2				1						2			1	1
Butte	2	11	4	4	4	3	2	1			1		2			1			1	1
Calaveras		1	5	1		1		1	3				1		3		1	1	1	2
Colusa		3		3	3	1	1	2	1			3			1	2	1	2	2	5
Contra Costa																				
Del Norte		8	13	4	11	11	23	4	1	9	4		5	1	4	4	2	8	6	4
Eldorado	2	8	2	1	8	8	6	1	1	2	1	1	8	6	14	7	3	3	4	13
Fresno		1	3	1		4		1	1	1	4	3	3	2	6	2	3	10	3	4
Glenn		12	6	6	1	4	5	1			1	2	2	3	3	10	1	4		2
Humboldt	10	108	60	71	42	49	41	46	26	39	29	22	7	19	16	14	10	11	13	13
Imperial									1					1						
Inyo					1			1	3	1			1		1		4	4		
Kern		9	10	12	7	7	10	5	18	18	17	9	14	12	8	18	21	21	14	20
Kings											1									
Lake	2	18	11	13	9	10	7	5	8	2	5	11	11	11	10	21	11	12	17	22
Lassen			1		2	1	1						1	1	2					
Los Angeles		7	1	2	1		3	5	5	1	7	7	8	10	7	5	3	4	3	3
Madera		4	5	1		1	1	9	9	1	2	1	6	1	1		1	2	2	1
Marin																				
Mariposa	2	3	3	6	2	1	3	9	2	14	13	12	7	7	6	7	5			13
Mendocino	5	43	18	11	16	17	20	15	7	7	15	19	23	13	17	22	21	15	30	20
Merced				1			1							1	1			8	1	
Modoc			1	1			1					1						1		
Mono								2		5				1	1	1		1	2	1
Monterey		15	11	7	1	4	9	3	8	6	12	11	19	13	8	16	16	30	23	26
Napa				1		2												1		
Nevada		1	1	1						2		2	1							
Orange			1	1	1						2	2								
Placer		5	4	1	2	8	3	3	1	4	2	2	3	9	13		5			6
Plumas		2		3			2				1					1				
Riverside		2	5			4	2			3	4	4	5	6			2	2	3	3
Sacramento													1							
San Benito		1	3	1	2	11	4	2	2	5	1	2	1	2	2	2	3	2	1	3
San Bernardino		5	2	1	2		2	1	2		1	4	5	6	2	4	3	6	10	5
San Diego		3	5	5	8	3	2	2	1	1	3	3	5	4	2		1	5	5	3
San Joaquin									2											
San Luis Obispo		10	5	9	4	3	5	7	11	3	9	3	7	11	12	13	10	8	5	5
San Mateo				1																
Santa Barbara		7	23	7	3	6	11	4	4	6	3	5	21	5	15	26	13	12	5	11
Santa Clara			4			1	1	1	1	4	2	1	4	4	4	1	10	4	3	3
Santa Cruz				1									1				2			
Shasta	1	26	33	30	29	28	22	9	7	10	11	23	32	8	9	37	16	16	17	11
Sierra		1				3	2													
Siskiyou	1	32	35	45	25	26	22	31	9	9	7	1		2	9	14	5	6	3	3
Sonoma			2	4	1	4	4	2		1	4	2	1	3		1				
Stanislaus			2		1				1		3	1			1				3	
Sutter						1														
Tehama	3	30	17	24	10	23	29	5	4	1	3	3	6	18	17	15	4	14	2	5
Trinity	9	88	41	32	22	15	11	13	4	3	2	10	19	13	26	19	11	16	15	11
Tulare		6	8	11	4	5	3	10	6	8	4	10	18	23	12	22	15	44	9	4
Tuolumne		6	10	5	2	4	1	2	7	11	6	8	13	4	15	13	11	4	1	11
Ventura		1	6	4	6	2		1	7	1	8	2	2	9	4	1	9	14	15	14
Yolo																				
Yuba		1			2								1				1	1	4	
Yearly totals	37	482	361	333	233	275	260	204	164	179	188	190	264	229	252	301	225	285	225	249

none; and Ventura with 168 killed and only 10 years with none. Only Humboldt, Lake, Mendocino, Shasta, Tehama and Trinity have continuous records of kill in every year since 1907. Kern, Monterey and Tulare lack only a kill in 1907 which covered only a three-month

TABLE 1—Continued

Record of Mountain Lion Bounties Paid by Division of Fish and Game

1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	'37	'38	'39	'40	'41	'42	'43	'44	'45	'46	'47	'48	'49	'50	Co. totals
----	----	----	----	----	1	2	----	1	----	----	----	----	1	----	----	1	----	----	2	4	5	1	8	29
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	3
1	1	3	4	----	2	1	----	1	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	27
1	1	2	----	1	3	1	3	4	2	1	----	4	1	----	3	3	----	----	2	----	1	2	6	78
3	9	3	1	----	9	1	4	----	2	2	1	1	3	1	----	----	----	----	1	----	----	----	----	62
3	2	4	8	8	8	----	4	4	----	1	----	1	2	----	----	----	----	----	1	3	3	1	3	86
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	1
9	5	8	2	4	8	3	1	4	4	6	11	7	8	5	1	----	1	1	2	1	----	8	----	221
17	5	7	15	8	10	5	13	3	3	8	----	2	6	3	6	1	2	1	7	----	4	5	4	234
12	7	----	6	9	4	2	4	----	4	3	6	16	2	7	19	3	2	2	12	6	7	1	3	189
1	10	2	15	14	18	9	5	7	8	9	11	7	5	7	6	12	14	7	3	12	5	11	7	268
15	10	21	22	13	19	29	22	28	19	24	25	28	17	22	7	5	19	11	18	24	6	17	18	1,085
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2
----	1	----	1	----	----	----	----	----	----	----	----	1	3	----	----	----	----	----	----	1	----	----	2	25
14	20	3	9	14	7	6	6	4	5	5	13	5	2	10	5	13	5	9	10	6	11	14	21	467
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
9	27	28	19	18	21	11	11	13	13	12	14	10	8	12	9	7	7	3	6	7	5	11	7	504
----	----	----	----	----	----	1	2	----	----	----	----	----	----	1	----	----	----	1	----	----	----	----	----	13
3	11	22	13	----	4	1	3	2	3	8	5	6	5	3	2	----	----	1	5	7	1	----	1	188
1	2	1	1	1	----	----	8	3	1	2	4	3	4	12	1	9	----	2	----	1	----	----	2	106
----	----	----	----	1	----	1	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	3
3	7	4	2	1	----	1	3	----	----	----	1	4	----	----	----	----	----	----	4	1	2	1	2	151
14	32	13	16	9	24	21	5	13	4	12	16	21	10	31	20	8	20	6	15	7	18	12	7	708
----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2	----	2	10
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	6
----	2	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	3	2	1	15	38
23	37	34	27	16	23	3	2	19	8	17	11	19	14	16	10	6	17	14	13	18	29	34	34	682
----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	4
----	1	----	----	3	1	4	6	1	----	1	1	5	----	1	----	----	1	----	1	----	----	1	----	36
----	----	----	----	----	2	----	----	----	2	----	----	----	5	----	----	----	----	----	----	----	----	----	----	16
3	1	6	----	3	2	9	1	5	3	----	7	4	2	----	----	----	----	----	----	----	----	1	----	118
----	----	----	1	2	1	----	3	1	----	----	----	----	1	----	----	----	----	----	----	----	----	----	2	20
----	4	2	2	1	2	7	6	8	1	2	3	----	3	2	----	5	5	1	5	1	1	1	1	108
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
1	1	1	----	1	2	3	2	----	----	----	1	----	----	----	----	----	1	3	----	1	----	----	1	68
5	7	4	7	1	5	7	8	2	7	4	4	15	8	6	2	2	1	7	5	4	3	1	----	176
10	7	34	5	14	15	5	12	12	12	14	4	11	10	6	6	2	----	2	9	8	10	8	4	281
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2
8	7	4	10	8	5	6	----	1	1	2	4	5	4	5	2	7	3	4	5	1	9	6	7	254
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
14	13	17	20	25	24	18	14	20	7	5	11	11	17	5	6	----	4	6	9	1	----	4	2	440
----	3	2	2	1	7	7	6	13	3	2	5	1	4	1	----	9	4	3	4	2	7	11	14	159
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	4
13	15	16	19	15	26	29	20	22	3	18	8	11	8	7	5	18	9	4	10	22	15	12	7	707
----	----	1	1	3	3	4	2	12	1	----	----	----	----	2	3	1	----	2	1	1	----	----	----	43
16	8	8	2	15	3	3	7	12	20	18	18	22	12	31	13	4	4	3	10	5	17	6	7	549
1	1	----	----	----	1	1	1	----	----	----	----	----	----	----	----	----	1	----	----	----	1	----	----	36
----	3	1	----	----	3	1	1	----	----	----	3	----	----	----	----	----	----	----	----	----	----	----	----	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
6	9	11	6	16	10	21	7	9	8	6	10	9	3	4	6	2	17	11	15	11	2	6	7	445
4	33	28	36	40	31	26	12	18	18	29	28	50	38	24	19	23	13	15	26	22	16	18	21	968
12	16	9	10	18	8	11	4	7	9	8	15	13	17	12	8	6	17	21	18	14	15	8	12	510
2	7	2	5	1	6	----	3	5	4	3	1	----	1	6	----	----	3	2	----	----	----	----	----	185
17	2	6	4	8	1	2	1	1	2	1	9	----	3	2	----	1	----	----	----	----	1	----	----	167
----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	2	----	----	----	----	----	----	3
----	5	1	1	1	5	6	3	----	----	1	2	----	----	----	3	2	5	----	----	----	----	----	----	45
241	332	309	292	293	325	269	215	255	177	224	253	292	228	243	162	150	177	143	219	195	199	202	227	10,558

period. Siskiyou had a kill each year except 1919. El Dorado lacked a kill in 1938 and 1947; San Luis Obispo lacked only 1907 and 1934.

It will be noted that only two counties are not represented in the kill statistics, San Francisco and, oddly enough, Solano. In regard to Solano County, it is surprising that there has been no kill bountied. Two lions have been killed on the eastern side of Napa County close to the Solano county line. The author has seen lion tracks twice in Solano County, once near the head of Miller Canyon on the north slope of Mt. Vaca, and once northeast of the Blue Mt. School on the road along the ridge top which is the boundary between Solano and Napa Counties.

Several counties have had only one lion reported for bounty. These are Contra Costa, Kings, Sacramento, San Mateo and Sutter Counties. Imperial and San Joaquin Counties have had two lions each bountied, while Alpine, Marin and Yolo Counties have reported three each.

TABLE 2

Sonoma County Lion Kill

1907 to 1916	18
1917 to 1926	11
1927 to 1936	5
1937 to 1946	1
1947 to 1950	1

TABLE 3

Siskiyou County Lion Kill

1907 to 1916	235
1917 to 1926	9
1927 to 1936	94
1937 to 1946	135
1947 to 1950	35

TABLE 4

Humboldt County Lion Kill

1907 to 1916	492
1917 to 1926	154
1927 to 1936	198
1937 to 1946	176
1947 to 1950	65

TABLE 5

Trinity County Lion Kill

1907 to 1916	238
1917 to 1926	142
1927 to 1936	246
1937 to 1946	265
1947 to 1950	77

The kill in any one county may not be in close ratio to the lion population. In many counties there are no properly equipped hunters interested in taking lions. Consequently there are several counties such as Alpine, Lassen and Plumas which have more lions than the kill would indicate. Mono County had produced a kill of only 23 lions until 1950, when two of the state hunters took 15 lions out of a small area in a relatively short period.

MOUNTAIN LION CONTROL

It should not be a policy to eliminate mountain lions from any area entirely unless a sudden rise in deer population is desired. It must be remembered that adult lions probably kill at least one deer a week per lion throughout the year. With an estimated adult lion population of 600 lions in the State a lion kill of at least 30,000 deer annually can be expected. Wholesale lion reduction in any area where deer are at all numerous is usually followed by a rise in the deer population such as occurred in Santa Clara County following a heavy lion kill in the 1930's. In this instance, 22 lions were killed in the Mt. Hamilton Range of this county from March, 1934, to March, 1936. This occurred within 550 square miles of lion range giving a kill of one lion for each 25 square miles. Such a kill is bound to be reflected in the deer population of an area. The deer did increase rapidly, and by 1940 were spreading out into the agricultural area and feeding on vineyards, orchards and other crops. By 1941, disease became active in the high deer population and by 1944, deer numbers reached a low of probably not over 40 percent of the total of 1939 or 1940.

The lion kill in the Mt. Hamilton area dropped accordingly. It remained low, except for 1943 when nine were killed by three hunters. In 1948, it began to rise with the increasing deer population. The annual average kill for Santa Clara County for the 44 years is 3.6 lions a year, with 159 lions killed. In 1948, an unusually high kill occurred with seven, in 1949 with 11 and in 1950 with 14 the highest on record. In 1935, there were 13 killed and in 1923 there were 10.

If we compare deer and lion kill statistics, it appears that the lion population reacts about two years behind the deer. In other words, when a low or high occurs in deer it takes about two years for a corresponding low or high to become apparent in the lion population of the area involved. However, the lion kill does not fluctuate as extremely as the deer. Perhaps the two-year lag is due to the fact that most lions do not breed oftener than every other year, and it takes nearly two years before the kittens become entirely independent. Similar predator-prey relationships have been noted, as for example, the one-year lag in the populations of snowy owls and Canada lynx in the far north, when the varying hare goes through its cycles in abundance.

LION HUNTERS

A resume of the activities of some of the lion hunters who have pursued lions in California is of particular interest in that some of these men became famous due to their vocation.

Jay C. Bruce, the most famous of all our California hunters, got his first bountied lion on February 18, 1914, near his home at Wawona,

Mariposa County. In 1919 he went on the payroll of the State Division of Fish and Game and worked for 28 years, killing his last lion to be turned in for bounty on September 17, 1946, for a total of 581. Besides this total of bountied lions, he probably caught close to 100 alive which he disposed of to zoological parks and private buyers. He was a born lion hunter and woodsman and in spite of losing one eye in the middle of his career, he continued on to take many more lions. At the present time, he is retired and living at Kelsey in El Dorado County.

The late C. W. Ledshaw, the second state lion hunter to be put on the payroll, was from Sonora in Tuolumne County. He turned in his first lion for bounty on March 24, 1919. Shortly thereafter he was employed by the Division of Fish and Game and worked continuously until his retirement. On October 9, 1947, he shot the last lion he turned in for bounty, his 342d.

He was a quiet, tall, wiry man and a born woodsman also.

Bruce and Ledshaw have taken more lions than the next 10 hunters all told; 922 versus 920. At present, there are four state lion hunters.

Many lions are killed by deer hunters each year and ranchers always kill a considerable number. Certain individual ranchers kill more than others, because they happen to have dogs that will tree them. It is the author's opinion that at the present time we are not gaining on the lion population, but are probably just holding the number about even or possibly losing a little ground.

FIELD REPORTING OF SUSPECTED WILDLIFE POISONING BY AGRICULTURAL CHEMICALS[1]

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Numerous insecticides and herbicides are now in field use for the purpose of protecting field crops. All of these under certain conditions of use may present hazards to wildlife. This paper presents a method for reporting observed field effects of these agents on wildlife. Also, some 21 insecticides and herbicides now commonly in use are described as to their use and possible effects on wildlife.

INTRODUCTION

Federal law requires that all economic poisons be tested carefully before they may be marketed in interstate commerce. The required testing program is conducted with laboratory animals under controlled conditions. Normally, a product cannot reach the market within less than two years after toxicological research has been initiated. Although testing on experimental animals may be exhaustive and competent, the impact of a given chemical on wildlife under diverse field conditions may only be suggested by usual premarket testing.

Commercial producers of chemicals, as well as others interested in side-effects of these chemicals, depend on experience derived from field use before establishing the hazards to wildlife. The reasons for dependence on postmarketing field usage are understandable to those with a familiarity with the difficulties of field research. To wildlife workers and to all those concerned with conservation of wildlife, the question remains, how may one assess quickly and accurately the hazard to wildlife of an agricultural chemical in field use? The answer is not a simple one.

Currently, even with much interest in the subject, it is not possible to give a satisfactory appraisal of the effects on wildlife of more than a few common agricultural chemicals. Before one may hope for such an appraisal, more information is needed from wildlife workers in the field. These workers should have a general familiarity with the chemicals in agricultural usage and with the type of information necessary in order to evaluate the effects of a chemical on wildlife. This paper is directed to wildlife workers to assist in acquiring this familiarity.

A number of points to observe when reporting on a specific instance of suspected poisoning are given. Not all of the desired information will be obtainable in every case, but a field worker should attempt to

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procure as much data as possible. All objective information, irrespective of amount, is helpful. One man's observations may well supplement another's.

A second section of this paper is composed of brief accounts of the use and hazards of 21 common agricultural chemicals or groups of chemicals. Many hundreds of chemicals and formulations are in agricultural use, each with its own toxicological properties. Chemicals listed in this paper were included because of their wide usage, their high toxicity, or a known history of damage to wildlife.

REQUIREMENTS FOR FIELD REPORTING

1. Determine the chemical applied and, when possible, obtain a label from the chemical container for later reference. Inquire of the farmer or pest control operator what formulation and rate of application were used. Note the type and condition of crop.
2. Record weather conditions of a day or two prior and subsequent to application of chemicals, or, if the effect on animals is delayed, from the time of application until the first observed effects; weathering usually decreases the toxicity of a chemical.
3. Determine all species of animals concerned and the condition of affected animals. Look particularly for unusual behavior in living animals. Evidences of extreme thirst, exaggerated posturing, or other abnormal behavior may often be observed in poisoned animals. If animals are dead, record their locations in relation to cover and the attitudes assumed at the time of death.
4. Attempt to decide in the field how the chemical was exposed to the animal and the nature of its action upon that animal. If the chemical affected the animal within a few hours, or at most a few days, the effect is best described as acute. If effects on the animal were delayed for several days or longer, poisoning was probably chronic in nature. By normal implication acute effects often result in death, whereas chronic effects seldom do. Actually, effects may be either mild or severe in both acute and chronic poisoning.
5. The effect on a population or the reproductive potential of a population may be of far greater biological significance than immediate mortality of a few individuals. Look for indications of change in population numbers and structure. Ideally, censuses before and after application of the chemical would be necessary to establish such a change. Low population numbers do not necessarily imply reduction due to chemical usage, since populations often vary in numbers from season to season or year to year due to environmental factors; nor does the failure to find dead animals in a treated area indicate a lack of effect on the animal population. Not only might there be sublethal effects, but sick or dying animals may escape detection by retreating to dense cover. In all cases investigate the possibility that disease, inclement weather, or other natural factors may have contributed to the observed effects on the animal population.

6. Preservation of specimens for later chemical analysis is essential if the absolute cause of death is to be established. The portions of the animals to be preserved depend on the nature of the suspected chemical. As a general rule, retain and freeze the entire, fresh animal if a chlorinated hydrocarbon is believed to be the agent responsible for the animal's death. If storage space is a problem, a liver sample will usually suffice. If an organic phosphate is the causative chemical, a blood sample from a recently killed animal is necessary. Blood should be treated with an anticoagulant such as heparin or "oxalate," and refrigerated for later analysis. Chemical techniques for the detection of organic phosphates in animal tissue are difficult. Many insecticides cannot be detected specifically by known chemical techniques, hence the need for adequate case histories.

In the final analysis, consultation with interested individuals and agencies is mandatory for a full appraisal of a chemical's effects on wildlife. Those interested would include local farmers, County Agricultural Commissioners, Department of Fish and Game patrol wardens and game managers, commercial producers of chemicals, and the University of California. In such consultations it is well to offer concrete suggestions on how wildlife loss may be eliminated or minimized. Different formulations or methods of applications may accomplish the same control purpose without undesirable side effects. Cultivation practices in some instances may obviate the need of chemical control. Biologists may offer information on daily or seasonal habits of animals which when integrated with control schedules would minimize animal exposure to chemicals.

INSECTICIDES

Most insecticides now in agricultural usage fall into two large chemical groups: the chlorinated hydrocarbons and the organic phosphates, which have come into use within the last 15 years. DDT appeared during the early years of World War II, but, as with most of the chemicals included in this report, it was not used widely until after that war. Active research on both new and established chemicals is currently in progress, and we look forward to the appearance of new agricultural chemicals and more information on those already in use.

Insecticides necessarily are poisonous. Some are highly toxic to both insects and vertebrates; others are highly efficient insecticidally, but have a low degree of vertebrate toxicity. All must be used with care, since none is without some hazard. Judiciously used, they will accomplish their primary purpose of insect control, while at the same time yielding no or minimal effect on wildlife.

Brief descriptions of 14 insecticides are given in this paper. All of them are in common usage; all are sufficiently toxic to constitute a hazard to wildlife under certain conditions of exposure. Each of them is sold in several formulations and under several trade names. In some instances the commercial name does not clearly imply the nature of the basic insecticidal ingredient. However, in all such cases close inspection of the label will identify the basic chemical.

Chlorinated Hydrocarbons

Aldrin. Aldrin, known earlier as compound 118, is used on forage crops, against soil insects, and is particularly effective as a grasshopper poison. It is applied on baits or as a dust or spray. Under field conditions, it persists for a shorter time than DDT, dieldrin, toxaphene and chlordane, and accordingly constitutes less of a residue problem than most chlorinated hydrocarbons. Its acute toxicity is slightly higher that DDT; its chronic toxicity is much higher. Wildlife managers in other states have been concerned about its use for grasshopper control on lands which also support high game bird populations.

Benzene Hexachloride or BHC. Crude BHC consists of several isomers, only one of which—the gamma isomer—has high insecticidal activity. Technical BHC normally contains 12 to 14 percent of this isomer. The refined product containing at least 99 percent of the gamma isomer is called lindane. BHC has limited use on edible crops, particularly root vegetables, because of the musty flavor which it imparts. Lindane imparts very little of this flavor, and is used effectively against soil insects for this reason. Both BHC and lindane are more toxic than DDT in acute dosages, but the chronic effects are less severe. Neither chemical accumulates or persists in tissue as much as DDT. There is no known hazard to wildlife from the use of BHC. It is suspected that birds may be repelled by BHC under some field conditions.

Chlordane. Chlordane, also known as Velsicol 1068, is prepared as dusts, wettable powders, or solutions for control of grasshoppers, cutworms, and household insects. Normally, chlordane decomposes quickly (two to three weeks) under field conditions. While not as toxic as DDT in a single dose, its chronic hazard is high. Ordinarily, it is not used on edible food crops. It may be used on animals in low concentrations to control parasites. Grasshopper control measures employing this chemical may present a chronic hazard to wildlife where heavy baiting is practiced.

DDD. This chemical, also known as TDE or "rhothane," is chemically similar to DDT and is about as effective as DDT against many insects. Normally, it persists for a shorter time than DDT. It is less toxic to warm blooded animals than DDT and is frequently used in place of DDT around domestic livestock. Like DDT, however, repeated exposure to DDD results in accumulation of significant amounts in fatty tissue. Control of the Clear Lake gnat without significant loss of fish and fish-food organisms was effected by this chemical.

DDT. DDT is the best known and most widely used of the chlorinated hydrocarbons. It has been used against almost all crop and household insects, but is not effective against aphids, mites, leaf miners, and certain resistant strains of insects. After repeated exposure, significant quantities concentrate in milk and fatty tissues, and as a result, it is not recommended for usage around warm-blooded animals or on forage crops to be consumed by livestock. Residual insecticidal activity is high since it may persist and remain toxic for a month or more under field conditions. Chronic effects of DDT are suspected in some game bird mortality on agricultural lands.

Dieldrin. Dieldrin (Compound 497) is chemically similar to aldrin, but is more persistent. It has been used on cotton and alfalfa, against leaf miners on tomatoes, beets and rice, and recently in fly and mosquito control. Dieldrin is a newly developed chemical, and the full extent of its possible uses and side effects is not known. Its acute toxicity is about that of aldrin, but its residual toxicity is much longer (as much or more than DDT depending on conditions of exposure). The acute toxicity of dieldrin is higher than DDT, and its chronic toxicity is relatively high. Apparently, dieldrin is readily absorbed through the skin. Fish and game birds were recently killed in significant numbers by dieldrin applied to control rice leaf miner.

Heptachlor. This new chemical, also known as Velsicol 104, is related to chlordane and is used in much the same manner as chlordane. Its toxicity approximates that of chlordane. Experiments indicate an accumulation in fatty tissues. Chronic effects may be expected for this reason.

Methoxychlor. This chemical, an analogue of DDT also known as DMDT or methoxy DDT, is used in about the same manner as DDT. Methoxychlor may be used more safely on such susceptible plants as cucumbers and tomatoes which are killed or injured by other common chlorinated hydrocarbons. Since it is not accumulated in fatty tissue to such an extent as DDT, it is commonly used on or around livestock. Since methoxychlor is less stable than DDT, it presents fewer problems of residual persistency and toxicity.

Toxaphene. Toxaphene, or chlorinated camphene, is an effective and widely used insecticide. It is used primarily on vegetable and forage crop insects, but may be used on livestock at low dilutions to control animal parasites. Like chlordane and aldrin, it is an effective grasshopper poison. Recently, it has been used successfully in mosquito control operations against strains of mosquitoes resistant to DDT. Experimental work has been in progress to determine its efficacy in field mouse control. Insect control normally requires one half to two pounds per acre; mouse control requires a dosage of four to six pounds of the actual chemical per acre. Toxaphene persists in soil for a month or more depending on weather conditions. It does not accumulate in tissues to an appreciable degree unless intake of the chemical is high. Toxaphene has been known to kill game birds at insecticidal and rodenticidal dosages.

Organic Phosphates

EPN (Ethyl p-nitrophenyl thionobenzenephosphonate). EPN is an excellent miticide. Most of the chlorinated hydrocarbons are ineffective against mites and aphids. EPN may be used on fruit tree and crop insects and is in use by some mosquito abatement districts. As with all organic phosphates, EPN may be used only by permit from the County Agricultural Commissioner. It has a longer residual action than the other organic phosphates and is much less toxic to warm-blooded animals than parathion. EPN has appeared relatively recently and much remains to be learned about its possible uses and hazards.

Malathion. Malathion is an effective insecticide and miticide with a low order of toxicity to vertebrates. Two or three times as much malathion as parathion may be required for comparable insect control. Acute and chronic effects on warm-blooded animals are less likely with malathion than with other organic phosphates.

Parathion. Parathion, also known as E605, is an effective miticide and insecticide (aphids particularly). Acute toxicity to warm-blooded animals is high, and as a result it is classified as an injurious material requiring a permit for its use. Many spray operators have become ill after exposure to parathion and several deaths have resulted from careless handling. The hazard involves inhalation of dust and absorption through the skin. Parathion is not stored in animal tissues to an appreciable extent but chronic effects due to continued depletion of the blood enzyme cholinesterase on which the organic phosphates act are possible. This depletion requires repeated exposure since parathion breaks down quickly after application. It is most safely applied as a wettable powder; dusts and oil preparations are more easily assimilated. Parathion is known to have killed some wildlife in citrus orchards.

TEPP (Tetraethyl pyrophosphate). TEPP is one of the most dangerous of all insecticides from the standpoint of inhalation and dermal toxicity during handling and application. Decomposition takes place within a day or two after application leaving no harmful residues. This capacity for rapid loss of toxicity permits the use of TEPP in many situations where more persistent chemicals could not be used. TEPP, like other organic phosphates, is particularly useful for mite and aphid control. A drifting spray of this chemical is a serious problem because of the extremely high acute toxicity. The hazard of TEPP to wildlife is inadequately known.

Plant Derivatives

Rotenone. Rotenone is the primary toxic element in such plants as *Derris* and *Lonchocarpus.* It is best known as a fish poison, par excellence, but it has been used considerably as an insecticide. Low toxicity to warm-blooded animals renders it desirable as a spray or dip for livestock parasites. For the same reason, it is recommended for the control of certain insects on home grown vegetable crops. Accidental pollution of streams after insecticidal applications of rotenone to livestock caused heavy fish mortality.

HERBICIDES

The acute toxicity of most herbicides to experimental animals is so low that poisoning under field conditions seems unlikely. The chronic effects of herbicides on animals in the field are unknown. Side effects which are of interest to biologists do occur, however. These effects are primarily ecological. Changes in the carrying capacity of game habitat may occur with alteration of the environment. Properly used, herbicides may allow much higher game populations simply by breaking up dense stands of vegetation. Work is in progress by the California Department of Fish and Game and other agencies to accomplish this purpose.

TCA (Trichloroacetic acid). Sodium and ammonium salts of trichloroacetic acid are particularly useful in the control of perennial grasses. Ordinarily TCA is used on noncrop land because of its persistency in soil.

Ammonium sulfamate. Ammonium sulfamate ("ammate") is a foliage spray used against woody species not controlled by 2,4-D or 2,4,5-T or where susceptibility of adjacent crop plants limits use of these chemicals. It may be used to prevent sprouting.

Sodium chlorate. This chemical is used as a general weed killer and as a defoliant or preharvest spray. When used in concentrations sufficiently high to kill certain weeds, it may sterilize the soil. Its use on crop lands is restricted on this account. Sodium chlorate is highly inflammable, and extreme care must be employed in its use.

2,4-D and 2,4,5-T. Various salts, esters and amines of 2,4-D and the closely related 2,4,5-T are used successfully for broad leaved weed and brush control. They are widely used on crop lands to control weeds in grain fields and as preharvest defoliants. According to some reports, 2,4-D may render certain plants toxic (by raising the potassium nitrate content to toxic levels), and toxic plants palatable. Further research is necessary before the significance of these effects to wildlife can be determined.

Dinitro Weed Killers. Phenol compounds of this group are used as general weed killers. They are soluble in oil, and are often used to fortify oils used as general contact weed killers. The water soluble salts of the dinitrophenols are used as selective weed killers for the removal of certain broad leaved weeds from some crop lands such as flax, peas and grains. As a group, the dinitrophenols are more toxic to warm-blooded animals than other herbicides in common agricultural usage. Inhalation and skin contact are particularly to be avoided.

Arsenicals. Arsenical herbicides constitute a serious hazard when carelessly applied. Sodium arsenite is particularly hazardous. Animals have died from its improper use. The arsenicals are extensively used around household and commercial installations and in the control of submerged aquatic plants. Although they are efficient and inexpensive weed killers, they are not normally applied on agricultural lands. Hazards are too great for large scale agricultural usage.

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DEER MARKING DEVICES[1]

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INTRODUCTION

The daily and seasonal movement of deer can be determined by sight records of marked animals. For many years, there has been a need for marking devices which would enable wildlife workers to mark deer economically. Such studies have been accomplished, normally, by trapping and marking, a costly procedure both in manpower and materials. In addition, areas of low deer population do not lend themselves well to wholesale trapping. The result is that so few deer are marked that sight or recovery records are rare when the animals are widely dispersed on their summer ranges. The need exists for accurate information of this nature in many areas of California.

Bearing this in mind, two marking devices have been developed and tested on two deer winter ranges in California. They are designed to propel liquid dye when the devices are tripped by passing deer.

ONE TIME MARKER

A shotgun shell marker was designed to mark deer in areas of low population density in rough terrain. This device is shown in Figure 1. It is constructed of a six-inch length of three-fourths inch pipe, half of a pipe sleeve, a pipe plug, a common nail, a rat trap, and a trip thread. A 12-guage shotgun shell serves as the propellant for the dye. An empty, primed shotgun shell is loaded with one-eighth dram of powder. Because of the small charge, it must be held centered over the primer by a small tuft of asbestos wool, or other similar fireproof material. A wad is forced into place and the remainder of the shell case cut off. The wad and the surrounding area must be sealed to prevent seepage to the powder. If the dye solvent is alcohol, it may be sealed with rubber cement. If thinner, petroleum spirits, or carbon tetrachloride is employed as the dye solvent, the shell and wad should be coated with a heavy grease.

To load, the shell is inserted in the firing chamber and the plug replaced.

The dye chamber is then ready for filling. In order to allow for expansion, the chamber is filled only about three-quarters full of dye. The chamber is plugged with a cork coated with rubber cement, or liberally coated with heavy grease. If dye leaks persistently around the firing pin, applying a small amount of water-pump grease over the inner hole

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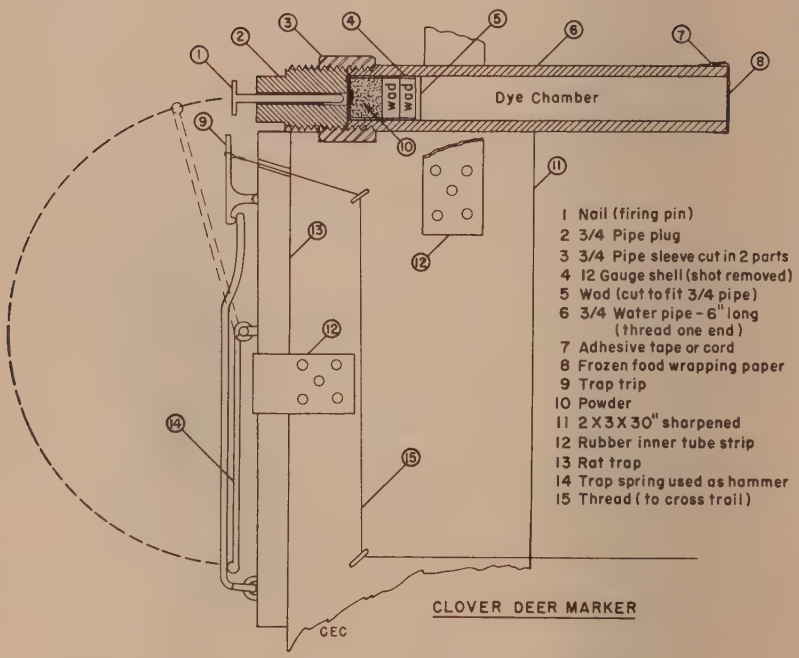
Dye Chamber
WAD
WAD
1 Nail (firing pin)
2 3/4 Pipe plug
3 3/4 Pipe sleeve cut in 2 parts
4 12 Gauge shell (shot removed)
5 Wad (cut to fit 3/4 pipe)
6 3/4 Water pipe – 6" long (thread one end)
7 Adhesive tape or cord
8 Frozen food wrapping paper
9 Trap trip
10 Powder
11 2X3X30" sharpened
12 Rubber inner tube strip
13 Rat trap
14 Trap spring used as hammer
15 Thread (to cross trail)
CLOVER DEER MARKER
CEC

FIGURE 1. Diagram of the Clover one shot deer marker.

of the plug prior to screwing it to the chamber will solve the problem. A dye-loaded shell was constructed to eliminate the nuisance of field-loading the chamber, but this has not been perfected at the time of writing.

Field Use of One Time Marker

For trail setting, a two by three inch post is driven into the ground about three feet from the deer trail. For California mule deer, the barrel should be about 25 inches above the ground level of the trail. The marker should be affixed to the post without the firing pin in place. Black nylon thread is run from the rat trap treadle across the trail and tied to a stake or brush. The thread should be about ten inches above the trail, so that the deer must hit it with its fore-legs. Properly set, passing deer should be marked on the shoulder despite the direction of travel. The rat trap is then set and the nail firing pin inserted. A safety set trap is preferable in order to lessen chances of accidental discharge.

Best results were obtained from a "line" of about twenty markers. The markers were checked each day that the deer were in the area, and less frequently when deer activity decreased. If the terrain allows the use of a vehicle, a "line" of a greater number of markers may be employed. Although the gun is not dangerous with the proper load, caution signs should be displayed prominently in areas receiving public use. Cut apples for bait placed on either side of the trip thread was

FIGURE 2. Field set of the Clover one shot deer marker. *Photograph by H. Hjersman, Department of Fish and Game.*

found to produce good results in areas where deer trails were not defined clearly.

AUTOMATIC MARKER

An automatic marker was designed for specific use on migration trails, or in areas of high concentrations of deer. This device consists of a pressure tank, a spray nozzle, and a release treadle. Pressure on the treadle causes a push-rod to open a valve which releases a stream

FIGURE 3. Field set of Clover one shot deer marker, showing location along deer trail. *Photograph by H. Bryan, Department of Fish and Game.*

of pressurized dye through the nozzle. Construction details are shown in Figure 4.

The tripping assembly is contained in a plywood box measuring eleven by thirty inches. At one end is placed the 24-inch head board which holds the pressure tank in position. The treadle is made of an eight by ten inch three-fourths inch plywood with four half inch cleats attached to prevent foot slippage. The top of the box overlaps the treadle one inch on each longitudinal side of the opening provision. This holds the treadle in position. A spring is placed around the wooden rod between the base and the treadle. A piece of inner tube is nailed over the treadle to exclude rocks and other debris. Two cleats are placed so that the downward motion of the treadle is restricted. Iron rods complete the articulation to the nozzle valve.

Field Use of Automatic Marker

Dig a rectangular hole about 14 inches wide, 36 inches long, and 10 inches deep beside a well travelled deer migration trail. When the box is buried, the treadle should be centered in the trail. Cover the box with about one inch of dirt. The head board and pressure tank should

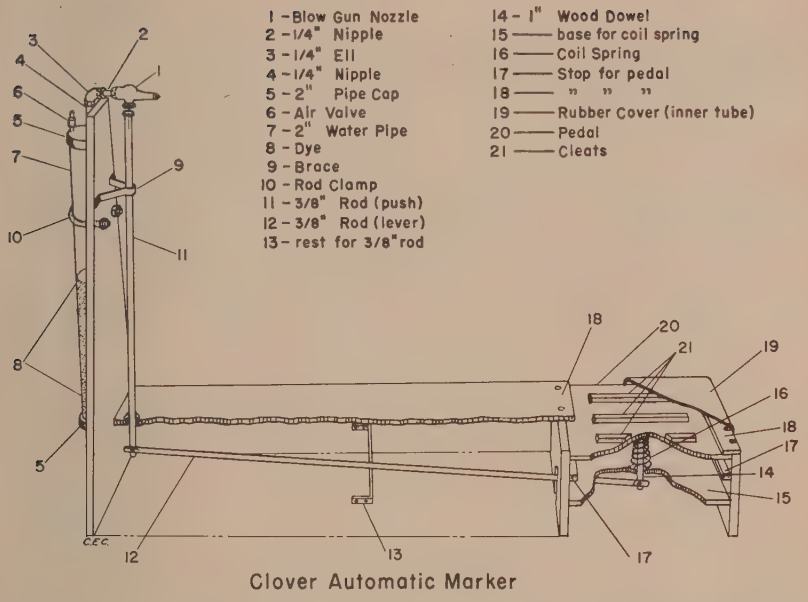
1 - Blow Gun Nozzle
2 - 1/4" Nipple
3 - 1/4" Ell
4 - 1/4" Nipple
5 - 2" Pipe Cap
6 - Air Valve
7 - 2" Water Pipe
8 - Dye
9 - Brace
10 - Rod Clamp
11 - 3/8" Rod (push)
12 - 3/8" Rod (lever)
13 - rest for 3/8" rod
14 - 1" Wood Dowel
15 —— base for coil spring
16 —— Coil Spring
17 —— Stop for pedal
18 —— " " "
19 —— Rubber Cover (inner tube)
20 —— Pedal
21 —— Cleats
Clover Automatic Marker
Calif. Dept. of Fish & Game

FIGURE 4. Diagram of Clover automatic deer marker.

FIGURE 5. Clover automatic deer marker before field setting. Rubber treadle cover removed to show cleats of treadle. *Photograph by author.*

FIGURE 6. Field set of Clover automatic deer marker. *Photograph by H. Hjersman, Department of Fish and Game.*

be camouflaged with conifer boughs, dead grass, or whatever native material is available. A veeder counter can be built into the actuating mechanism so that the presumed markings may be registered.

The advantage of this type of marker is that it requires but little attention. In a test, one marker was tripped over 100 times before the air and dye were exhausted. If the pressure tank is assembled carefully, it should be possible to introduce 120 pounds of air pressure safely. This is sufficient to expel all of the dye if the chamber is filled to just half capacity.

DISCUSSION

The advantages of these markers are ease of construction, low cost, and simple maintenance. They will propel liquid dye accurately for several feet. Aniline dye disolved in lacquer thinner was used with good success in the one time marker. This cannot be used in the automatic marker, as clogging of the spray nozzle is the inevitable result. For automatic use, aniline dye was dissolved with alcohol to which was added 1/15th part of nitric acid. The dye alone has a tendency to fade in about six weeks, but the nitric acid still shows its effect on the pelage without being harmful to the skin.

The main difficulty encountered in marking deer on winter ranges is that the animals soon shed their winter coats and the dye. Further investigation is required in order to develop a dye or depilatory which will allow easy recognition of the marked animals on their summer ranges.

SUMMARY

A one time and an automatic deer marker have been developed at low cost which have successfully marked deer. The dye retention period is sufficiently long, so that following marked animals along at least a major portion of the spring migration route may be accomplished. Present limitations involve the inability to recognize marked animals on their summer range, as the marking has been done in areas of winter concentration.

DATA ON THE LIFE HISTORY, VARIATION, ECOLOGY, AND RELATIONSHIPS OF THE KELP PERCH, *BRACHYISTIUS FRENATUS*, AN EMBIOTOCID FISH OF THE CALIFORNIAS[1]

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This study was prompted by the publication of a revision of the Embiotocidae, a family of viviparous fishes of the North Pacific (Tarp, 1952). Some of the generic fusions adopted in that paper may well be accepted, others not. By far the least justified, in our opinion, was the synonymizing of *Brachyistius* with the very highly specialized genus *Micrometrus*. Since *Micrometrus*, along with the closely related genus *Amphigonopterus*, is charactized by outstanding peculiarities in life history, variation, and ecology, as well as in morphology (Hubbs, 1918, 1921), we undertook a preliminary study, in sufficient detail to determine whether *Brachyistius* agrees or disagrees with *Micrometrus* in these respects.

[1] Bulletin of the Scripps Institution of Oceanography, New Series, No. 688. Submitted for publication November, 1953.

FIGURE 1. *Brachyistius frenatus:* photograph made by Scripps Institution of Oceanography, with stroboscope, of a live specimen from La Jolla, California, collected by Conrad Limbaugh, in the fall of 1951.

The life-history and variational data on *Brachyistius frenatus,* the kelp perch (Figure 1), were taken on a collection of 350 specimens, including 13 term embryos, obtained with the aid of derris in the dense bed of giant kelp, *Macrocystis pyrifera*, off La Jolla Point, California, on August 1, 1950. The collection was undertaken by the ichthyology staffs of Scripps Institution of Oceanography and the University of California (Los Angeles), to sample as quantitatively as possible the fish life in the kelp bed, from surface to bottom. The sampling in the restricted area was extensive, but not wholly representative, although every effort was made to distribute the derris effectively and to secure all specimens possible, both from the surface, by dip-netting from skiffs, and underwater, by swimming with the aid of self-contained diving gear. Gulls made away with many surfacing specimens, including probably several hundred kelp perch, but they seemed to take the larger adults of this very small species as well as the young. It is thought that the sample of *Brachyistius frenatus* obtained is reasonably representative for the intitial and general life-history determinations that we now need. Undoubtedly the collection is by far the largest of the species ever made.

LIFE HISTORY

Life-history features of *Micrometrus* and *Amphigonopterus* for which we wished to determine the agreement or disagreement of *Brachyistius* are (1) the highly unique feature of the natal maturity of the males; (2) the slow growth rate and small size attained, a much less significant feature shared with the shiner perch, *Cymatogaster aggregata* Gibbons; (3) great sexual dimorphism in size, due to the slower growth and lesser viability of the males.

Age at First Maturity

Examination of the primary as well as the secondary sex organs of the 13 term embryos, including seven males, and of nearly all the 337 other specimens demonstrated that the males of *Brachyistius frenatus,* unlike those of *Micrometrus minimus*, the dwarf perch, and *Amphigonopterus aurora,* the reef perch (Hubbs, 1921), never mature before birth, or within several weeks thereafter. In this important biological respect, therefore, *Brachyistius* disagrees with the two micrometrins. In the natal maturity of the males, *Micrometrus* and *Amphigonopterus* are apparently unique among acanthopterygian fishes. The only other fish genera that we know to approach the micrometrins in this respect are the extremely neotenic pelagic *Schindleria*, and three cyprinodont genera, *Girardinichthys* and *Lermichthys* (Goodeidae) and *Cynolebias* (Cyprinodontidae). It has been held (Hubbs, 1921, p. 189) that another small embiotocid, *Cymatogaster aggregata*, matures before birth, but an examination of late embryos and of young born both in nature and in aquaria shows that the statement was incorrect. A life-history feature so unique as natal maturity surely is a strong indication of high specialization and of a long and independent line of evolution. The physiological adjustments involved must be profound.

As in *Cymatogaster*, which we think may be the most closely related genus, the males and females of *Brachyistius* seem to mature for the first time late in the first year of life. Of the young-of-the-year males taken on August 1, all of the smaller were definitely immature and some of the larger were maturing, in a proportion increasing with size. All of the older males, mostly and perhaps all yearlings, were mature. Of the females, all young-of-the-year were immature and the older ones, except for three still carrying embryos at this late date, were spent or apparently spent. The age at first parturition is one year. It remains to be determined just when copulation, sperm storage, fertilization, and embryogenesis take place. (Tables 1 and 2.)

Growth and Size

The data for the August 1 collection, consistent with other miscellaneous observations on this species and with general information on the life history of the viviparous perches, indicate, for southern California populations, that *Brachyistius frenatus* is born, in small numbers per female, at a standard length of about 32 to 33 mm., usually in the spring, rarely as late as August; that by August 1 the standard length of each sex ranges to 77 mm., with most of the young about 50 to 75 mm. long; that the usual size of the next size group, largely and probably all yearlings, reaches about 85 to 105 mm. by August 1; and that a few females, likely two years old, reach the length of at least 114 mm. (Tables 1 and 2, Figure 2). It seems improbable that many individuals live to the age of two years.

The 13 embryos of the August 1 collection, all 32 or 33 mm. in standard length, were taken from three females, 5 from one 88 mm. long, and 3 and 5, respectively, from females 93 mm. long. The smallest free-living young measures 33 mm.; five others, 34 to 37 mm. Their darkened pigmentation suggests that they had been born at least several days, perhaps a week or two previously. It is probable that in this species as in other embiotocids, growth ceases for several days, perhaps for a week or two—long enough to induce the formation of the natal annulus on the scales.

The skewed curve of size frequency for the free-living young of the year, with only 10 (3 percent) less than 48 mm. long, the small proportion (11 percent) of yearling and older females still carrying young, all full term, and the breeding habits of the family in general, indicate that the chief season of parturition is spring. There is no reason to infer that either the new-born young or the oldest fish occupy any other habitat, for the very extensive local collecting in surface waters, on the bottom, and on and just off the rocky reefs, has yielded too few specimens to suggest that the young live elsewhere than in the kelp beds. Growth after the formation of the natal annulus is probably rather slow, modally about 30 mm. by August 1. If the young are born chiefly about June 1, this would indicate an average daily increase of only 0.5 mm.

The specimens from 34 to 77 mm. long are judged to comprise the 0 age-group (the 1950 year-class) because of their size distribution and because all 13 fish aged of the 46 that are 68-77 mm. long, including 9 of the 13 that are 73-77 mm. long, have scales with no winter mark

TABLE 1

Size Frequency Data by Sex and Maturity for Brachyistius frenatus Taken in the La Jolla Kelp Bed on August 1, 1950

Sex and maturity	Standard length to nearest 5 mm.																	
	30[a]	35[a]	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115
Males, immature	3	8	2	1	9	23	33	35	8	1	--	--	--	--	--	--	--	--
maturing	--	--	--	--	--	--	--	5	6	1	--	--	--	--	--	--	--	--
mature	--	--	--	--	--	--	--	--	--	--	--	3	5	3	3	1	--	--
Females, immature	3	5	1	1	12	33	50	38	19	11	--	--	--	--	--	--	--	--
with young	--	--	--	--	--	--	--	--	--	--	--	--	1	2	--	--	--	--
spent[b]	--	--	--	--	--	--	--	--	--	--	--	2	7	8	4	1	--	2
Total males[c]	3	8	2	1	9	23	33	40	14	2	--	3	5	3	3	1	--	--
Total females[c]	3	5	1	1	12	33	50	38	19	11	--	2	8	10	4	1	--	2
Grand total	6	13	3	2	21	56	83	78	33	13	--	5	13	13	7	2	--	2

[a] Including 6 embryos 32 mm. long and 7 embryos 33 mm. long.
[b] Including some probably spent.
[c] Graphed in Figure 2.

TABLE 2

Number and Size, According to Age and Sex, of Specimens of Brachyistius frenatus Taken in the La Jolla Kelp Bed on August 1, 1950

Age and size	Specimens	Size range, mm. (Standard length)	Mean size, mm.
Term embryos, males	7	32–33	32.6
females	6	32–33	32.5
total	13	32–33	32.5
Young-of-the-year, males	128	33–77	60.5
females	167	34–77	60.9
total	295	33–77	60.7
Older fish, males	15	84–104	92.7
females	27	85–114	95.2
total	42	84–114	94.3

(only the natal annulus). The few fish of the next size group examined have, as expected, one winter annulus in addition to the natal mark.

The data indicate that the average growth increment from the first to the second summer is about 33 mm., or approximately the same as either the growth *in utero* or the modal increment between birth and August 1. The increase through the first year of maturity is very small.

The largest specimen in the August 1 collection, 114 mm. in standard length, is about the maximum that we have collected in southern California. Conrad Limbaugh, however, has seen some larger females about the Coronado Islands in May and June. The 35 specimens measured by Tarp (1952, p. 88) ranged to 121.5 mm. in standard length, but the largest probably came from central California, where on the average a greater length may be attained.

Relative Size and Number of Sexes

In *Amphigonopterus aurora,* as previously indicated (Hubbs, 1921) and in *Micrometrus minimus,* as a study of many collections has shown, the females markedly outnumber the males, except before and soon after birth. For both species additional data have confirmed the conclusion published in 1921, that the males not only die off sooner than the females, but also grow more slowly, so that the adults average much smaller. The size difference is already striking in yearlings, during the first period of maturity of females but the second season of breeding by the males. In correlation with the fact that they do not mature at birth the yearling males of *Brachyistius frenatus* are approximately of the same size range as the females and average almost as large (Figure 2). The slightly higher average indicated for the females measured may be due to the inclusion of two older fish. The ratio of males to females appears to decrease with age, as it does in *Micrometrus* and *Amphigonopterus,* but a similar decrease appears to take place in *Cymatogaster* and in other genera.

It is evident that in fundamental life-history features *Brachyistius* diverges notably from *Micrometrus* and *Amphigonopterus* and shows no agreement with these genera that is not shared also with *Cymatogaster.*

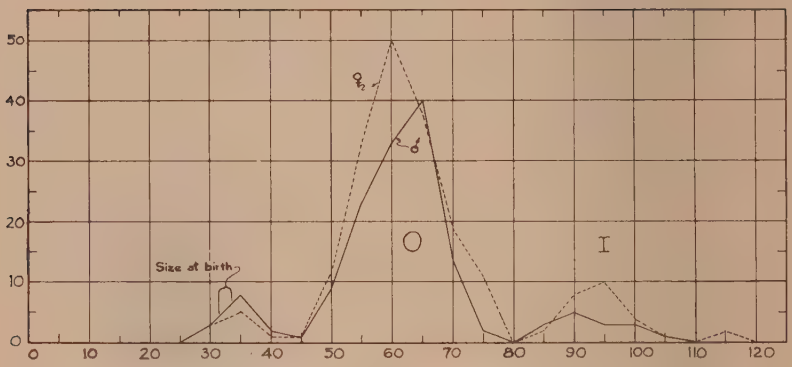

FIGURE 2. Size frequency distribution by sexes of 350 specimens of *Brachyistius frenatus* collected August 1, 1950.

SEXUAL VARIATION

We find that *Brachyistius frenatus* agrees with all embiotocids other than *Micrometrus minimus* and *Amphigonopterus aurora* and with nearly all other fishes in the essential identity of the sexes in the number of dorsal and anal rays (Table 3, Figure 3). The vertebrae have not been counted, but there is no reason to expect sexual dimorphism in their number. New counts of hundreds of specimens of *Micrometrus* and of *Amphigonopterus* confirm the previous findings (Hubbs, 1918) that in both these genera the males have more anal rays than the female, with relatively little overlap, and that on the average the males have more dorsal soft-rays and fewer dorsal spines, more caudal vertebrae, fewer precaudal vertebrae, and slightly more total vertebrae. The only other fishes in which there has been found more than a very slight average difference in the number of anal fin rays are the several species of *Cynoletbias,* of the family Cyprinodontidae (Regan, 1913,

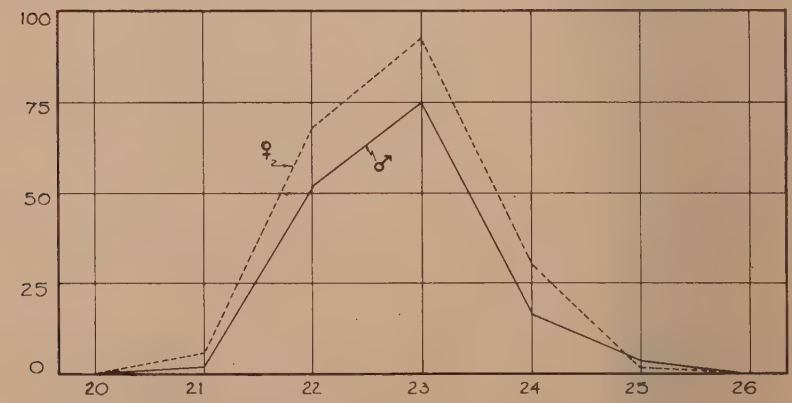

FIGURE 3. Frequency distribution of numbers of anal soft-rays in 350 specimens of *Brachyistius frenatus* collected August 1, 1950.

TABLE 3

Lack of Sexual Differences in the Number of Dorsal and Anal Fin Rays in Brachyistius frenatus
Based on the 150 males and 200 females collected August 1, 1950

Dorsal spines	7	8	9	10	No.	Mean	S. E.
Males	1	77	71	1	150	8.48	0.04
Females	--	96	103	1	200	8.525	0.04
Total	1	173	174	2	350	8.51	0.03

Dorsal soft-rays	13	14	15	16	No.	Mean	S. E.
Males	12	98	40	--	150	14.19	0.05
Females	19	118	59	4	200	14.24	0.05
Total	31	216	99	4	350	14.22	0.03

Anal soft-rays	21	22	23	24	25	No.	Mean	S. E.
Males [a]	2	52	75	17	4	150	22.79	0.06
Females [a]	6	68	93	31	2	200	22.775	0.06
Total	8	120	168	48	6	350	22.78	0.04

[a] Graphed in Figure 3.

p. 641-642; Myers, 1952) and the single species each of *Girardinichthys* and *Lermichthys,* of the Goodeidae (Hubbs and Turner, 1939). In these three genera, as Regan showed for *Cynolebias* and as Hubbs and Turner and also Robert Rush Miller have shown in unpublished studies for the two goodeids, the anal rays are, with very limited overlap, more numerous in males than in females. Some of the other smaller goodeids have on the average more anal rays in the male.

In the marked sexual variation in the number of anal rays, as well as in the natal maturity of the males, *Micrometrus* and *Amphigonopterus* are so far as known unique among all acanthopterygian fishes. These two highly distinctive features appear to be related. Embryological studies of *Micrometrus* and *Amphigonopterus* (made with the assistance of Elizabeth M. Kampa) show that fin-ray formation is not completed before the sexual dimorphism in body form has become established. In correlation with the need in these small viviparous fish for extra room in the female, to provide for adequate broods of the very large embryos, the abdomen in the female becomes longer and the urosome compensatingly shorter. Since the males and females are of the same size at birth, the shorter urosome of the female provides less space for fin rays than does the longer urosome of the male. Various studies have indicated that meristic parts are laid down at approximately constant absolute sizes, so that the number of parts is roughly proportional to the available space (Hubbs, 1941). An explanation is thus provided for the higher number of anal rays in the males of

Micrometrus and *Amphigonopterus* and for the other sexual differences in meristic counts in these genera. On the same basis it appears possible to explain the high number of anal rays in the males of *Cynolebias, Girardinichthys,* and *Lermichthys,* which also mature at or very soon after birth.

Since the sexes of *Brachyistius* do not differ in fin-ray number, this genus differs very strikingly from the micrometrins. The difference is almost surely very fundamental and of long standing, though it is accorded bare mention by Tarp (1952, p. 19, 87).

In counting the number of rays in *Brachyistius* we have followed the criteria recommended by Hubbs and Lagler (1947, p. 8-10). The usual condition in Embiotocidae, normal for most fishes, is a more or less close fore-and-aft apposition of the two elements of the last ray, but with the separation complete, in the concealed base as well as in the main exposed part of the fin. Tarp (1952, p. 23) wrote that "the last ray of the dorsal and anal fin was counted as $1\frac{1}{2}$ if it was split to the base," but he listed no $\frac{1}{2}$ count for any species, though the normal situation is for the last ray to be completely divided through its extreme base. The $\frac{1}{2}$ count is awkward and totally unnecessary. It would appear that Tarp, despite his stated criterion, usually enumerated the rays in Embiotocidae as virtually all ichthyologists have, for fishes, including embioticids, that typically have the two elements of the last ray closely approximated. Tarp added, however, that if the last ray "was close to, but not visibly joined on the surface to the penultimate ray, it was counted as distinct." It is not clear whether he so referred to the unusual variants having the two elements of the last ray variably more separated than usual, or to the usual condition, in which the complete separation of the closely approximated elements of the last ray was disregarded. Tarp's range of counts for *Brachyistius frenatus* agrees with ours, except that he listed no variants with 10 dorsal spines and none with 25 anal soft-rays (which is not unexpected, since he had fewer specimens).

Occasionally in *Brachyistius* as in other spiny-rayed fishes one encounters, particularly at the junction of the spinous and soft parts of the dorsal fin, a ray that is intermediate between a spine and a soft-ray. If in postembryonic stages such a ray has any articulations it is listed as a soft-ray, no matter how spine-like the basal part may be. One of the 350 specimens has such a ray, definitely like a spine except for the articulated tip. Two others have the last spine as slender as a soft-ray, but since it shows none of the technical features of a soft-ray, it is enumerated as a spine. The smallest free-living specimen (33 mm.) retains one suture on the last dorsal spine. In the embryo this ray, like the third anal ray, begins as an articulated soft-ray, but gradually becomes transformed into a typical spine. Such transformation of the third anal ray was first determined for the mullets (Mugilidae) but is characteristic also of other families, as the Gerridae and the Embiotocidae. These rays, of course, are tallied as spines.

TABLE 4

Seasonal Variation in Number of Dorsal and Anal Rays in Brachyistius frenatus

Based on 308 fish-of-the-year collected August 1, 1950. The values are the means and, in parentheses, the standard errors, plus or minus.

Size-class		Number	Dorsal spines	Dorsal soft-rays	Anal soft-rays	These rays combined
mm.	Median					
32–52	42	45	8.40 (.07)	14.22 (.08)	22.69 (.10)	48.29 (.15)
53–57	55	56	8.43 (.07)	14.29 (.09)	22.75 (.09)	48.46 (.14)
58–62	60	83	8.51 (.05)	14.16 (.07)	22.82 (.09)	48.48 (.13)
63–67	65	78	8.54 (.06)	14.17 (.07)	22.71 (.08)	48.41 (.13)
68–77	72.5	46	8.65 (.08)	14.43 (.09)	23.22 (.12)	49.30 (.16)

SEASONAL VARIATION

Other variational analyses, made feasible by the large series of counts in a single collection, are here presented, though they do not bear on the main theme of the distinctiveness of *Brachyistius*. The first analysis (Table 4) pertains to seasonal variation. It has commonly been observed that the average number of parts developed, as of vertebrae and fin rays, decreases for spring-spawning fishes as the season advances and as the temperature during critical stages of development increases. In the present analysis, as is usual, the time of development is inferred from the size of the fish: the larger the fish, the earlier the development. The analysis is restricted to the 308 young of the year, for it is not safe to infer time of early development for yearling or older fish. The sexes are combined, since the data indicate no significant sexual dimorphism in the counts. The five-millimeter size-groups (Table 1) were combined as evenly as possible into classes with 45 to 83 specimens.

For dorsal spines, for dorsal soft-rays, for anal soft-rays, and for all these rays combined, the smallest size-class has fewer rays on the average than the largest class and the intermediate size-classes combined as a unit have intermediate averages for each comparison and intermediate averages for 10 of the 12 cases. The differences between the means for the smallest and the largest classes are of highly probable, though not entirely certain, significance: the differences between the means exceeds the standard error of the difference (the square root of the sum of the squares of the two standard errors) about 2.5 times for the dorsal spines, nearly 2 times for the dorsal soft-rays, more than 3 times for the anal soft-rays, and nearly 5 times (highly trustworthy) for all these rays combined. As is usual, the larger fish in the late-summer sample, that is, those that probably developed in the cooler water, have the higher average number of rays.

FIN-RAY CORRELATIONS

The fin-ray counts of the 350 specimens of *Brachyistius* taken on August 1, 1950, in the La Jolla kelp bed were tabulated in two ways (Tables 5-6) to see if this species agrees with the general rules, (1) that the elements in the anterior and posterior divisions of a single series are negatively correlated, and (2) that the elements in dorsoventrally or bilaterally opposed series are positively correlated. When the test is

TABLE 5

Fin-Ray Correlations in Brachyistius frenatus, Based on 350 Specimens Collected August 1, 1950

Dorsal spines	Dorsal soft-rays				Dorsal soft-rays	Anal soft-rays				
	13	14	15	16		21	22	23	24	25
7	--	--	1	--	13	3	15	11	2	--
8	2	87	81	3	14	5	80	101	28	2
9	29	127	17	1	15	--	25	55	15	4
10	--	2	--	--	16	--	--	1	3	--
	$r = -0.47 \pm 0.04$					$r = +0.24 \pm 0.05$				

Total dorsal rays	Total anal rays				
	24	25	26	27	28
21	--	2	--	--	--
22	6	61	46	5	--
23	2	54	112	35	4
24	--	3	10	7	2
25	--	--	--	1	--

$r = +0.38 \pm 0.05$

TABLE 6

Association of Low and High Counts in One Fin With Low and High Counts in Other Fin
(Data from Table 5)
Based on 350 specimens collected August 1, 1950

Dorsal spines	D soft-rays		Dorsal soft-rays	A soft-rays		Dorsal rays	A rays	
	13-14	15-16		21-22	23-25		24-25	26-28
7-8	89	85	13-14	103	144	21-22	69	51
9-10	158	18	15-16	25	78	23-25	59	171
	Chi-square=63 P=<0.01			Chi-square=9.5 P=<0.01			Chi-square=34 P=<0.01	

made on the basis of the coefficient of correlation (r), indications are obtained of a moderate negative correlation (—0.47) between dorsal spines and dorsal soft-rays, a rather lower positive correlation (+0.38) between total dorsal and total anal rays, and a relatively low positive correlation (+0.24) between dorsal soft-rays and anal soft-rays. Coefficients of correlation of such magnitudes are commonly discredited, but added reliance is afforded by their agreement with the general rule.

Another statistical approach is to test by the chi-square method the association of low and of high counts in one fin with the low and the high counts in the other fin (Table 6). Highly trustworthy associations are indicated.

VARIATION IN RAYS IN OTHER FINS

Deviations in the number of anal spines from the normal (III) are extremely rare among the Embiotocidae, although noted by Tarp (1952, p. 41) for *Amphistichus argenteus* and by us for *Micrometrus minimus* and *Amphigonopterus aurora*. All specimens of *Brachyistius frenatus* counted (the 350 in one collection plus more than 20 in other series) have three anal spines.

Nor was any variation noted in the caudal count. In the 346 specimens with uninjured caudal fins in the large collection and in 8 specimens from other collections the count of principal rays is $7 + 7 = 14$. This appears to be the normal caudal ray formula for the Embiotocidae in general. Increasingly, distinctive caudal ray counts are being indicated as often of family or even higher than family significance, though of only generic and specific value in other groups, as Cyprinodontes and Heterosomata. Tarp (1952, p. 23) stated that he counted the principal caudal rays (that is, the branched rays plus 2), but he failed to record any counts or to mention the normal number.

The pelvic ray formula was I, 5 (normal for all Embiotocidae and for most spiny-rayed fishes) in 349 of the 350 specimens of *Brachyistius* comprising the large series and in 8 specimens from other places. The one variant had I, 4 rays in the left fin, which appeared fully normal and uninjured, and I, 5 in the right fin. A few deviations from the normal were noted by us in our extensive study of variation in *Micrometrus* and *Amphigonopterus*, emphasizing the principle that no meristic structure has an invariable number of parts.

ECOLOGY

The striking difference between *Brachyistius* and *Micrometrus* (as well as *Amphigonopterus*) in the usual habitat is another important biological distinction. *Brachyistius frenatus* is very intimately associated with the giant kelps, particularly with *Macrocystis*, whereas the two micrometrins are typically inhabitants of the exposed rocky reefs (Hubbs, 1921). *Amphigonopterus aurora* in its two regions (Central California and northwestern Baja California) appears to live exclusively in the intertidal belt, usually in rather open, shallow pools. *Micrometrus minimus* frequently occurs in rocky tide pools and is usually restricted to the inner margins of rocky reefs, though some live in coves between the rocky stretches and some inhabit the eel-grass (*Zostera*) of bays; a few wander out to a depth of a few fathoms, but stay near the bottom.

Brachyistius frenatus, in contrast, rarely approaches the intertidal belt of the reefs and very seldom occurs in tide pools. A few wander along the coast away from the giant kelp, but probably 95 percent or more of the total population lives in the kelp, at all ages. A few have been taken in traps set as deep as 90 feet. The normal habitat is at mid-depths among the rising columns of the kelp. The fish is well adapted to this habitat. Its color, typically more constant than indicated by Tarp (1952, p. 89), usually matches that of the kelp very closely, and seldom deviates far therefrom (individuals from deep water, however, may be deep orange). In the rather strongly oblique, almost superior position of the mouth it is typical of mid-water feeders and contrasts with the browsing micrometrins. The high and rather sharp fins with thin spines and delicate soft-rays befit such a fish.

The conclusions regarding the habitat of *Brachyistius frenatus* stem from extensive collecting particularly in Southern California and Baja California; from hundreds of hours of critical underwater observation in the kelp and elsewhere in California and Baja California, particularly by Conrad Limbaugh; and from repeated observations of the fish caught by the kelp harvesters. The collection from the La Jolla kelp bed that yielded 350 specimens of this species, not counting the several hundred seen to be eaten by gulls, contained in addition relatively few specimens of other embiotocids, namely *Embiotoca* sp. (4), rainbow seaperch, *Hypsurus caryi* (1), rubberlip perch, *Rhacochilus toxotes* (observed only), and pile perch, *Damalichthys vacca* (3).

A second species of *Brachyistius* was described by Tarp (1952, p. 89-90) as *Micrometrus* (*Brachyistius*) *aletes*, from Guadalupe Island, where we do not find typical kelp beds. We have obtained testimony indicating the occurrence of kelp beds around Guadalupe about 25 years ago and it seems not improbable that *Brachyistius aletes* lived among kelp when the specimens were collected in 1897 and 1911. At present it lives in and about *Sargassum* and *Eisenia,* which here form dense growths several feet high. In the crystal-clear waters about the island, *Brachyistius* descends to depths as great as 150 feet (Conrad Limbaugh, personal communication).

We have found floating drift kelp (*Macrocystis, Pelagophycus,* and *Nereocystis*) about Guadalupe Island and suspect that *Brachyistius* reached the island long ago with drifting kelp. Tarp (1952, p. 19), on the contrary, stated that "when Guadalupe Island was isolated from the mainland in fairly recent geological times, individuals from the mainland ancestral stock were isolated with it," and, further, that "through the joint action of geographical isolation and selection *M. aletes* arose." These statements violate the convincing evidence, geological and biological, that Guadalupe is an oceanic island.

In retaining carnivorous habits *Brachyistius frenatus* differs further from *Micrometrus* and *Amphigonopterus,* which are unique, in the family, in being chiefly (*Micrometrus*) or almost exclusively (*Amphigonopterus*) herbivorous, beyond the earliest free-living stage (Hubbs, 1921; Conrad Limbaugh, personal communication). Mr. Limbaugh has observed *Brachyistius frenatus* nibbling food material off the kelp. He has also seen it feeding, as *Oxyjulis* often does, on the ectoparasites of other fishes, which submit willingly to this cooperative act. In general,

Brachyistius and *Oxyjulis* have similar feeding habits, and, as noted below, similar dentition.

RELATIONSHIPS AND NOMENCLATURE

We thus find that *Brachyistius frenatus* diverges widely from *Micrometrus minimus* and *Amphigonopterus aurora* in various fundamental features of life-history, variation, habitat, and food, in which respects *Micrometrus* and *Amphigonopterus* are unique in the family (in two respects, natal maturity of the males and a strong sexual dimorphism in the number of anal rays, unique among all spiny-rayed fishes). Such considerations are of greater significance in judging relationships than even rather profound differences in morphology, certainly vastly more indicative of genetic ties than the few superficial similarities that led Tarp (1952) to synonymize *Brachyistius* with *Micrometrus,* recognizing it only as a subgenus.

It is difficult to ferret out the reasons for the reference of *Brachyistius frenatus* to *Micrometrus.* Tarp presented an entirely artificial (though useful) key, with no attempt at natural groupings and his discussions of generic relationships are interwoven in a speculative and unfruitful attempt to retrace the phyletic history of the family in terms of both space and time. Particular stress seems to have been placed on the finding in *Brachyistius aletes* of a blackish axillary crescent approaching that of *Micrometrus minimus* and *Amphigonopterus aurora*—surely a very superficial feature. Stress was also laid on the short dorsal fin base and the correspondingly long interval between the dorsal and caudal fins, in which minor respects *B. frenatus* agrees somewhat better with *M. minimus* and *A. aurora* than with *Cymatogaster aggregata* and *C. gracilis.* But the proportional measurements given by Tarp indicate that species of other genera overlap those of *Micrometrus* (in the sense of Tarp) and those of *Cymatogaster.* The agreement between *Brachyistius* on the one hand and *Micrometrus* and *Amphigonopterus* on the other in the small size attained and in the large size of the scales is no justification for generic fusion, for in these rather superficial respects all three genera agree essentially with *Cymatogaster,* which genus we regard as probably the nearest living relative of *Brachyistius.*

There are very adequate morphological grounds for the generic separation, at least, of *Brachyistius* from the Micrometrini (*Micrometrus* and *Amphigonopterus*). The differences in structure far transcend the few items of agreement. The teeth of the jaws are conic instead of being very broad incisors, rendered tricuspid by the expansion of the shoulders. A few of the lateral teeth in the micrometrins may be nearly conic, but Tarp (1952, p. 82) underestimated the distinctiveness of the dentition of the micrometrins, unique in the family, by stating, "teeth very often tricuspid, but the constancy of this character is not marked." There are other striking differences in dentition. The teeth form a somewhat irregular series of points rather than an even crenate cutting edge. The teeth are weak to obsolete on the side of the jaws, instead of extending evenly around onto the sides. Much as in such labrids as *Oxyjulis californica* there are two to four canines at the front of the lower jaw and four closely approximated canines at the front of the upper jaw, whereas in the micrometrins

there is no specialization of the teeth at the front of the jaws. The mouth of *Brachyistius* is strongly oblique, largely on a level with the eye, and somewhat superior (with the lower jaw projecting), rather than being subhorizontal, largely or wholly below the level of the eye, and slightly inferior (with the lower jaw weakly included)—in all, fitted for grazing plants off the rocks rather than for snapping up small animals in mid-water. In correlation with the mouth structure the muzzle in *Brachyistius* is much more prominent than in the micrometrins and the top of the head is convex instead of concave.

The whole structure of the integument and fins in *Brachyistius* is more delicate than in the micrometrins. The spines and soft-rays are much thinner. The lower pectoral rays are scarcely instead of notably free and silky. The dorsal spines are graduated almost to the end rather than forming a rounded or flat-topped fin. The anal fin is sharply elevated at the front instead of being flat or rounded. In the adult males this sharp anterior elevation of the fin becomes exaggerated, greatly so in high males, and other sexually dimorphic differences appear, further emphasizing the increasingly evident principle that such sex-limited characters in fishes as well as in insects and other groups are of prime taxonomic significance. The spines become shortened and the first soft-ray considerably thickened. The sixth to eighth rays, lying under the main part of the thickened glands, become weakened, sometimes extremely weak, while the ninth to eleventh rays, under the end of the glands and just behind them, become very much strengthened and widened (except near base and tip), so that the articulations become linear horizontally. The interradial membranes here are thickened and opaque. The several following rays are more or less modified in the same direction. In high males the thickened rays are so widened as to be in contact, forming together a rather solid plate. In the Micrometrini the spines do not become much shortened in the adult males and the first soft-ray is not particularly thickened. The soft-rays under the middle part of the glandular area (about the fifth to eighth)—the very ones that are weakened in *Brachyistius*—are moderately strengthened and widened. And the rays over the end of the glands and just behind—the ones that become so greatly thickened in *Brachyistius*—are definitely weaker than those to either side. Nowhere do the rays broaden into mutual contact.

A more sharply marked difference is the lack in *Brachyistius* of the deeply concave, fine-scaled oval depression on the body above the front of the anal fin (a structure that seems designed to receive the anal spines of the female during amplexus). This structure was used (Hubbs, 1918) as a criterion of subfamily Micrometrinae (comprising *Micrometrus* and *Amphigonopterus*), but, as Tarp has shown, a similar though smaller and less highly differentiated structure (very possibly, we think, of independent origin) characterizes certain other genera (*Cymatogaster*, *Ditrema*, *Neoditrema*, and *Hysterocarpus*). In his phyletic discussion (p. 17-21) Tarp laid stress on the development of this structure, which he renamed the "lunar-shaped depression," and he included *Brachyistius* in the evolutionary line developing this feature, stating (p. 87): "occasionally a very slight depression found in the body surface of the male, dorsal to the anterior portion of the anal fin, adumbrates the conspicuous concavity which characterizes the sub-

genus *Micrometrus.*'' But we fail to find the structure (which involves much more than a mere concavity) in *Brachyistius.*

Tarp's valuable discovery of additional features separating the Amphistichinae from all other embiotocids—a separation that we still further confirm—renders it logical to follow Tarp in dividing the family first into the Amphistichinae and the Embiotocinae. The subfamily Micrometrinae (Hubbs, 1918) should, we feel, be subordinated to tribal rank, as the Micrometrini. We accord the same rank to the very distinctive freshwater genus *Hysterocarpus,* recognizing for it the tribe Hysterocarpini. Prior to 1918, when it was classed in the Embiotocinae by Hubbs (and when tribal rankings were not recognized in ichthyology), *Hysterocarpus* was regarded as the type of a distinct subfamily. Both groups seem to us to call for more than generic separation and their distinction as tribes within the Embiotocinae contrasts them satisfactorily with all the other genera, which may constitute the tribe Embiotocini.

Within the Micrometrini we recognize two monotypic genera, *Micrometrus* and *Amphigonopterus.* The characters heretofore used to separate *Amphigonopterus* (Hubbs, 1918) seem on the basis of current trends of thought hardly adequate to justify generic separation, but on further examination we now discover much more trenchant characters, involving fundamental differences in the genitalia of the female and in the complex architecture of the oval depression in each sex, justifying, in our opinion, the recognition of both genera. These differences are outlined in a manuscript, in preparation, dealing with the taxonomy of the whole family.

SUMMARY

A study of the viviparous embiotocid fish *Brachyistius frenatus* of western North America, based chiefly on a collection of 350 specimens, shows that this species differs greatly and fundamentally from *Micrometrus minimus* and *Amphigonopterus aurora* in various features of life history, variation, and ecology, as well as in morphology. The males do not mature earlier than late in the first year of life, rather than before birth (in the natal maturity of the males *Micrometrus minimus* and *Amphigonopterus aurora* are unique among all spiny-rayed fishes). Growth is slow: the standard length at birth, which appears to take place chiefly in the spring, rarely as late as August 1, is 32 or 33 mm.; by August 1 the average length has nearly doubled, to about 60 mm.; by the next August 1 the length at birth has hardly trebled (to about 90 or 95 mm.). The sexes of *Brachyistius,* unlike those of *Micrometrus* and *Amphigonopterus,* grow at about the same rate during the second as well as the first year of life. At one year of age, females first give birth to young. A few females may live to be two years old. The ratio of males to females appears to decrease with age.

In having the number of rays in the dorsal and anal fins the same in the two sexes *Brachyistius* further differs fundamentally from *Micrometrus* and *Amphigonopterus,* in which the marked sexual dimorphism in number of rays, particularly in the anal fin (unique among spiny-rayed fishes), is attributable to the attainment of adult proportions before birth (the greater length of the abdomen in the late

female embryos, attained before the formation of rays is complete, leaves less room for anal rays to form in that sex).

In *Brachyistius frenatus* the average number of rays formed appears to decrease as the season advances and as the developing fish are subjected to increasingly higher temperatures, since in the August 1 collection the largest (first-born) fish of the year have on the average more rays than the smallest, last-born fish. In agreement with the general rules that the number of elements in the anterior and posterior parts of a single series are negatively correlated and that the number of elements in opposed parts are positively correlated, we find a negative correlation between the numbers of dorsal spines and of dorsal soft-rays and a positive correlation between the numbers of dorsal and anal rays. The number of anal spines in the 350 specimens is invariably 3, the principal caudal rays number 7 + 7 in all 346 counted. One specimen among 350 had 4 pelvic soft-rays on one side.

In being carnivorous *Brachyistius* differs further from the almost strictly herbivorous *Micrometrus* and *Amphigonopterus*. Unlike those reef-inhabiting genera, *Brachyistius* is almost confined to the beds of giant kelp, particularly *Macrocystis*, where it lives chiefly in midwater. Its characters are adaptive to its habitat and way of life. Its dentition is quite different from that of *Micrometrus* and *Amphigonopterus* and there are other notable morphological differences, particularly in the sexual modifications of the anal fin and in the lack of the oval depression near the anal fin, which is elaborately and distinctively developed in *Micrometrus* and *Amphigonopterus*. *Brachyistius* appears to be more closely related to *Cymatogaster* than to *Micrometrus* and *Amphigonopterus*. On the basis of present evidence it seems best to divide the Embiotocidae first into two subfamilies, Amphistichinae and Embiotocinae, and to recognize three tribes in the Embiotocinae, namely Embiotocini, Micrometrini for *Micrometrus* and *Amphigonopterus*, and Hysterocarpini for the fresh-water genus *Hysterocarpus*.

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THE PISMO CLAM IN 1952 AND 1953[1]

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The 1952 Pismo clam census was conducted by members of the Marine Fisheries Branch, at Pismo Beach and Morro Bay during December 14-18. The regular sections, Le Grande, Oceano, Pismo and Morro (Fitch, 1952), were sampled and a fifth section was dug approximately three-fourths of a mile south of the Cayucos pier.

At all of these stations a rather flat beach and a strong inshore wind caused a high and heavy surf which continuously inundated the digging area. For this reason the 1952 census is not directly comparable with either that of 1953 or those of the several immediate preceding years.

The 1953 census, November 18-22, included the regular sections, at Pismo Beach and Morro Beaches. At Cayucos the section was moved to a locality some 40 yards south of the town pier in search of a more productive locality.

In both 1952 and 1953 the Oceano, Morro and Cayucos sections were made within the boundaries of clam preserves, while the Pismo and Le Grande sections were made in areas where public digging was permitted.

From these censuses it is evident that clam recruitment at Pismo Beach was exceptionally poor from 1946 until 1952 and was again poor in 1953. At Morro Bay there have been no worthwhile sets of clams since 1944. The condition or conditions causing these fluctuations in year class strength have not been determined. The number of legal clams in the closed areas (clam sanctuaries) has increased notably each year and the number of clams over four years of age has remained rather stable (Fitch, 1952). These facts indicate that short-term closures are desirable from the point of view of both sportsmen and biologists.

Detailed information regarding former censuses has been presented by Aplin (1947), Fitch (1950), and Collyer (1951).

LE GRANDE SECTION

This section which lies within the boundaries of a former clam refuge (Fitch 1950, 1952), yielded but five clams in 1952 and 14 in 1953. These two censuses, taken 38 and 49 months after the sanctuary was opened to the public indicate the clam population on this stretch of beach had reached the lowest ebb in the entire history of our Pismo clam studies. In 1952 unfavorable weather undoubtedly contributed to the poor results, but digging conditions were considered better than average for

[1] Submitted for publication December, 1953.

TABLE 1

Number of Clams, by Age Group, Taken in the Le Grande Section in 1952 and 1953

Year	Age group									Total
	0	I	II	III	IV	V	VI	VII	VIII+	
1952	1	0	0	0	0	0	3	1	0	5
1953	0	0	0	0	0	6	4	2	2	14

the 1953 census. In 1952, four of the five clams were over four years of age (Table 1) but none was of legal size (five inches in greatest diameter). Of the 14 taken in 1953, all were over four years of age but only one had attained legal size.

OCEANO SECTION

This section lies in an area which is closed to digging. Here, as in the Le Grande section, weather conditions made it physically impossible to make a good census in 1952, and only nine clams were found (Table 2). Eight of these were of the 1952 year class and the ninth, age four, was not of legal size. The heavy surf prevented digging much below mid-tide, and finding no legal clams in the upper tidal zone was to be expected. In 1953, conditions were ideal and 149 clams were taken, 28 of which were from the 1952 year class. Of the 121 clams age four and older, 44 had attained legal size. This stretch of beach was made a clam sanctuary in 1949. For clams four years and older the censuses indicate an increasing percentage of legal clams: 4 percent in 1949, 14.8 in 1950, 18.6 in 1951, 36.4 in 1953.

TABLE 2

Number of Clams, by Age Group, Taken in the Oceano Section in 1952 and 1953

Year	Age group									Total
	0	I	II	III	IV	V	VI	VII	VIII+	
1952	8	0	0	0	1	0	0	0	0	9
1953	0	28	0	0	1	5	9	50	56	149

PISMO SECTION

Digging in this section during the 1952 census was greatly hampered by the heavy surf which was almost continuously rolling across the sand flats. In spite of the water inundating the digging area a total of 26 clams was taken (Table 3), 19 of these were of the 1952 year class and the remaining seven were five years and older; there were none of legal size. In 1953, of 68 clams, 49 were in age group one and of the remaining 19 (age groups five through ten) 13 were of the 1946

TABLE 3

Number of Clams, by Age Group, Taken in the Pismo Section in 1952 and 1953

Year	Age group									Total
	0	I	II	III	IV	V	VI	VII	VIII+	
1952	19	0	0	0	0	1	4	0	2	26
1953	0	49	0	0	0	1	2	13	3	68

year class, age group seven. Two were of legal size. This portion of the beach is open to digging.

MORRO SECTION

This section, first censused in 1949 after having been made a clam sanctuary, has shown poor survival of young clams. In 1951, 16 clams of the year were found (Fitch, 1952), but in 1952 and 1953 not one of the 1951 year class was taken. The 1952 census yielded 14 clams of the year while in 1953 at age one, five of the 1952 year class were dug (Table 4). Of the 24 clams age four and older found in the 1953 census, 14 or 58 percent, were of legal size.

TABLE 4

Number of Clams, by Age Group, Taken in the Morro Section in 1952 and 1953

Year	Age group									Total
	0	I	II	III	IV	V	VI	VII	VIII+	
1952	14	0	0	0	0	0	0	0	0	14
1953	0	5	0	0	0	0	0	3	21	29

CAYUCOS SECTION

The Cayucos area, first sampled in 1949, has consistently been the least productive clam beach of those examined. The first year, 28 clams were dug, 18 of which were age zero. In 1950 but three clams were found, in 1951 and 1952 the yield was zero, and in 1953, one.

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THE INTRODUCTION OF THE REDEYE BLACK BASS AND THE THREADFIN SHAD INTO CALIFORNIA[1]

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A large part of the warmwater fisheries research program of the California Department of Fish and Game has been devoted to a search for new game species to be used in some of the State's marginal waters. Most of the streams and lakes now in this class furnish little or no sport fishing and while some of these waters might conceivably be suitable for trout, most of them tend to be more suitable for warmwater species. The possibility of finding new forage fishes has also been investigated. Research carried out by Inland Fisheries Branch biologists has indicated that a lack of a suitable forage species is probably the greatest deterrent to the warmwater fishing in our fluctuating reservoirs. The rapid drawdown of these waters frequently severely limits the spawning success of most of our present forage fishes and virtually eliminates food production in the important littoral zone.

Early in 1953 two species of fishes were selected for experimental introductions and in November, 1953, through the cooperation of the Tennessee Game and Fish Department, they were brought out from Tennessee by the California Department of Fish and Game by airplane.

Redeye black bass. *Micropterus coosae* Hubbs and Bailey.

Forty individuals of this species were secured from Sheeds Creek, tributary to the Conasauga River in southeastern Tennessee. Thirty-nine reached California alive on November 11, 1953, and are now being held in spawning ponds at Central Valleys Fish Hatchery, Elk Grove.

This fish is common in Georgia, Alabama, and parts of Tennessee, where it is primarily a fish of the small upland streams that are poor producers of other warmwater game species and trout. It is considered by most fishermen in its home range to be scrappy, colorful, and highly palatable. It is readily taken with artificial lures, although in Tennessee live bait proves most successful in the smaller, less turbid streams.

There are many streams in California that are unsuitable for trout because of high summer temperatures. In addition, they do not meet the requirements of most warmwater fishes because of their small size, low average temperatures, and swift current. The management problem presented by these streams is a difficult one and the redeye or Coosa black bass appears to be the game species that would most likely adapt itself to such waters. Experimental stocking will be carried out in 1954.

[1] Submitted for publication January, 1954.

Threadfin shad. *Signalosa petenensis atchafalayae* Evermann & Kendall.

Approximately 3,150 individuals of this species were seined from the Tennessee River about 2½ miles below Watts Bar Dam. The mean fork length of 161 specimens collected November 6, 1953, was 2.7 inches, with a range of 2.2 to 3.2 inches (fork length equals 0.851 times total length). Out of this initial number, a total of 314 live threadfin shad arrived by air in California and were planted in brood ponds in San Diego County. Following is a list of the exact planting localities:

	Number of fish
Circle R Ranch Pond on Dougherty Ranch property immediately west of U. S. Highway 395 about nine miles north of Escondido. T10S, R3W, Section 36. Tributary to Moosa Creek, San Diego County. November 11 and 18, 1953	135
Bates Pond on Bates Bros. Ranch about three miles east of Valley Center. T11S, R1W, Section 20. Tributary to Moosa Creek, San Diego County. November 11, 18, and 21, 1953	87
Wire Mountain Pond located one mile south of Van Dergriff Road on the Camp Pendleton Marine Base about three miles east of U. S. Highway 101. Tributary to Santa Margarita River, San Diego County. November 18, 1953	50
Valley Center Game Farm Holding Pond. Tributary to Moosa Creek, San Diego County. November 18, 1953	42
Total	314

The threadfin shad is extremely fragile and difficult to transport. It is believed that it will be an excellent forage species for our fluctuating reservoirs, since it requires no substrate for spawning, feeds on plankton, does not exceed about seven inches in length, and is very acceptable to game species as food. It appears to have none of the undesirable characteristics of the gizzard shad, *Dorosoma cepedianum*. It is not dependent during its life cycle on the littoral zone, which is so unstable in fluctuating reservoirs.

REVIEWS

A Guide to Bird Finding West of the Mississippi

By Olin Sewall Pettengill, Jr., Oxford University Press, New York, 1953. xxiv + 709 p., illustrations by George Miksch Sutton. $6.00.

At last bird enthusiasts who travel in the western states have a guide to good bird finding locations. Mr. Pettengill, with the cooperation of over 300 bird watchers, each of whom contributed information, has prepared a book which deals only with places where characteristic birds of any region may be observed. Identifications and study of birds are not covered, though at the end of the book are suggested references of available guides. Locations for bird finding were chosen with the over-all purpose of showing species of birds; important bird concentrations such as breeding colonies and wintering aggregations; representative type of bird habitats, from seashore to mountaintops; and the widest diversity of birds existing in the vicinity of all large metropolitan areas and leading vacation centers. Clear instructions, keyed to road maps and their route numbers, are given for reaching the locations. For many locations instructions are given as to where to park the car; best vantage point for observation; special equipment that may be needed; and the best overnight accommodations nearby.

A chapter is devoted to each of the 22 states lying wholly, or in part (Minnesota and Louisiana), west of the Mississippi. Each chapter consists of an introduction and a series of bird-finding locations. The introduction briefly describes the ornithology of the state, furnishes information of the physiographic regions, biological communities, migrations, and winter concentrations. In most of the chapters, an attempt is made to show, by a series of inclusive dates, when the peak flights of migrating birds occur.

Mr. Pettengill has done an excellent job of preparing the text. The style is clear and concise. The 35 small line drawings by George Miksch Sutton scattered through the book are well done, and illustrate some of the representative birds of the western states. An index is provided which is easy to use and is quite comprehensive.

Some advanced bird finders will be disappointed in that rare, accidental, and questionable species are omitted and that subspecies are ignored for the most part. Since many subspecies are seldom identifiable in the field this does not materially detract from the value of the book.

As the scope of the book is limited to locations only, its usefulness will naturally be restricted to bird finders, but for these individuals it should prove as indispensable as Peterson's "Guide to Western Birds" and a good pair of binoculars.—*James Gilman, California Department of Fish and Game.*

Hunting and Fishing in North America

By Michael Cramond; University of Oklahoma Press, Norman, 1953; xiii + 394 p, illustrated. $5.95.

This easy reading compendium of hunting and fishing experiences is concerned primarily with western North America. The angling portion is of lesser importance than that dealing with hunting, but even that contains good practical information concerning tackle and angling methods. The author's first love is hunting and his favored game vary from grizzly bear to iguana. The only major game species which he has not covered is the mourning dove. He admits that he doesn't like to hunt squirrels—in fact, he places them on his predator list.

The section relating to hunting equipment and methods is especially good. I found his discussions logical and convincing, although the .30-06 devotee will probably take exception to some of the statements. The hunting experiences are frequently thrillingly written, but they are underlain with an air of authenticity. Grizzly bear charges, mountain lion screams, "noodling" for catfish, and scrambling over rock

slides after Rocky Mountain goats are indicative of the scope of the work. The occasionally injected earthy humor is excellent, but not necessary to maintain reader interest.

Personal observations of natural history are included, for the author effectively points out that a thorough knowledge of the habits of game animals and fish is needed before a person can lay claim to being a "hunter" or a "fisherman." It is a book for enjoyment and, as the author stated, "Don't look for anything very scientific, because I don't know anything very scientific." My only real criticism is concerned with instances where the author does plunge into scientific names of animals. If he had been content to use common names, or had these portions checked carefully by a competent wildlife expert, the confusion in regard to pheasants and elk would not have occurred.

In addition to 24 pages of carefully selected photographs, the book is decorated with more than 35 drawings by Olaus J. Murie, president of the Wilderness Society. —*Henry A. Hjersman, California Department of Fish and Game.*

Hunting Crows Year Round

By Charles S. Adams; The Macmillan Company, New York, 1953; xix + 101 p., illustrated. $2.95.

In this book, the author has comprehensively outlined almost every phase of crow hunting. The book is divided into four parts, in which he discusses hunting in spring, summer, autumn and winter. The hunting methods described for each season could be successfully applied from Maine to California. In the foreword, the author projects his regard for the crow as a "great American game bird" and, at the same time, almost regretfully shows that he realizes that the crow must be controlled. Throughout the book, he emphasizes crow shooting as a sport which can be indulged in when more popular game is out of season.

The illustrations for blind construction are in sufficient detail to satisfy the complete novice and the photographs and diagrams are so profuse that they almost spell out the various "setups" a hunter would choose to make to fit any season or locality. The use of decoys and calls is described, and their importance properly stressed.

For the sake of convenience the subject matter has been indexed, and even the amateur photographer could profit by the camera settings so carefully logged in the appendix.

An insight into the author's character was revealed by the warm relationship that was apparent between himself, his son and his shooting partners. His friendly style should make the reading interesting for any sportsman and the contents, while a definite asset to the beginner, should still be of keen interest to anyone who has already enjoyed the sport of crow shooting.—*George Seymour, California Department of Fish and Game.*

Land and Water Trails

By Ellsworth Jaeger; The Macmillan Company, New York, 1953; ix + 227 p., 108 illustrations. $2.95.

In this book, the author imparts to the reader a knowledge of the outdoors through a profusely illustrated book very suggestive of the "Handbook for Boys" used by the Boy Scouts.

The first chapter is entitled "Water Travels" and covers rather extensively the modes of travel used on water both at present and in the past. However, the instructions as to "How to Build a Skiff" would, from my experience, seem to be oversimplified.

The second chapter, "Saddle and Bridle," is devoted to land travel and is concerned with horse anatomy and how horses may be mounted, ridden and cared for. Instructions on the use of burros are also included.

This book contains a very informative chapter on "Knots and Lashings." Natural history accounts of mammals, birds and even insects and how to recognize the signs of these animals are given.

The book is best suited to the needs of the novice, but the experienced camper may find some valuable advice and natural history knowledge. Certainly the author has accumulated a wide fund of knowledge over many years of outdoor experience. —*Howard Leach, California Department of Fish and Game.*

Lives of Game Animals

By Ernest Thompson Seton; Charles T. Branford Co., Boston, Mass., 1953; 4 vols. in 8; approx. 3,200 p. and 1,500 illustrations. $50.

"Lives of Game Animals" was first published in 1909. It is one of the best known and most widely used sources of information on game animals. The present printing was made to answer a continuing demand for the set, which has been out of print for years.

The scope, of course, is exhaustive, as indicated by the size of the set. It covers 105 animals of the following groups in America north of Mexico, which have been considered to be game either by attention of sportsmen or by legislative protection: cats, wolves, foxes, bears, raccoons, badger, weasels, deer, antelope, buffalo, sheep, peccary, squirrels, rabbits, armadillo and opossum.

The taxomic status of each species is dealt with; each species and subspecies is described physically; and the ranges are given. The greater bulk of each of the "Lives" is devoted to facets of life history in which abundant quotations from other publications are made. Subheadings such as "Haunts," "Sociability," and "Education of the Cubs" are liberally used, though much will be missed if selective reading is attempted on the basis of these.

It is hardly appropriate to launch into a detailed discourse of such a standard work as this. It is unlikely that any naturalist has missed reading through the volumes, unless by design. The chief value of a review in this case is to make known the fact that "Lives of Game Animals" is again available. Purchasers may, however, be somewhat disappointed in the quality of some of the illustrations, particularly the photographs, which have suffered considerably in the reproduction.

Since these volumes were first published, a vast quantity of detailed information on game animals has been accumulated. Understandably, then, glaring gaps appear to exist. This does not detract from the value of the work to modern naturalists, however. It is probable that other men have had the extensive field work of Ernest Thompson Seton, but it is certain that the wide scope of his "Lives" has not yet been met.—*Fred L. Jones, California Department of Fish and Game.*

Keeping and Breeding Aquarium Fishes

By C. W. Emmens; Academic Press, Inc., New York, 1953; 202 p., 82 figs. $4.50.

As the author states in his preface, most aquarium books are concerned with the identification of aquarium fishes and their pecularities. The present book, in contrast, is devoted very largely to their physiological requirements and to aquarium maintenance. This approach is understandable, since the author is Professor of Veterinary Physiology at the University of Sidney, Australia.

Although the author is not an American, the book was printed in this country and seems to be aimed at the "over 10,000,000 aquarium keepers" in the United States. In addition, it should have some appeal to fisheries workers, especially those concerned with game or food fish culture.

Many fisheries workers may not realize that a great deal more is known about the habits of most aquarium fishes than is known about those of many sport and commercial species. This statement must be qualified by adding that the knowledge of the aquarist is not concerned with the fish's ecology in nature but with its habits in the somewhat unnatural surroundings of the aquarium. The knowledge of aquarium fishes comes from a far more intimate association of the man with his pets than is possible in a study of wild fish. Despite the fact that some aquarium fishes do not behave in quite the same manner as they do in the wild, the essential pattern of living remains the same. The observing fish lover, separated from his little friends by nothing more than a clear pane of glass, learns much which is obscure to the student of wild fish.

The author explores the subjects of aquarium lighting and heating more thoroughly than do other books available to the hobbyist, perhaps even too thoroughly for many of his readers. There is some information on aeration which is pertinent to trout culture as well as to the culture of aquarium fish.

This reviewer is pleased by the author's frequent admission of lack of knowledge. There is no attempt to cover up the questions that have not been fully answered.

Readers of *California Fish and Game* may read this book with benefit, whether they keep aquarium fishes or not.—*J. H. Wales, California Department of Fish and Game.*

How Animals Move

By James Gray; Cambridge University Press, London and New York, 1953; xii + 114 p.; 15 halftone pls., 52 text figs., $3.00.

Professor James Gray of the University of Cambridge first familiarizes his reader with some of the fundamental laws of physics governing motion. The remainder of the volume is filled with interesting and thought-provoking facts covering all the different methods of animal locomotion encompassed in the terms swimming, walking, running, jumping, creeping and flying. Illustrations by Edward Bawden clearly demonstrate varying aspects of animal movement and these and the photographs assist greatly in giving the reader a clearer understanding of living creatures.

A question frequently posed to fish workers concerns the species and speed of the fastest fish. To answer this one may consult a dozen handy references or learned volumes and obtain a dozen conflicting and confusing explanations. While most of these are vague, they range from ultra conservatism to gross exaggeration. Professor Gray in discusssing speeds of fish cites a series of experiments employing trout and a high-speed camera. The answers derived are extremely interesting and certainly bring one closer to the final reckoning. However, much research is yet to be done before the speediest fish can be pointed out with assurance. The author shows how nature's design for a dolphin, a mammal known to maintain speeds of 20-25 m.p.h., is much more efficient than any submarine or torpedo yet produced. He also states that if he were asked to pick nature's fastest swimmer he would undoubtedly choose the dolphin; with this I heartily concur.

The sections on fish comprise but a small portion of the whole, and the same thoroughness and care is apparent throughout whether applied to snakes, newts, fleas, grasshoppers, flies, pigeons, bats, horses or man. The locomotion of these and numerous others is analyzed and explained in a manner readily understandable to the average citizen with little biological background.—*John E. Fitch, California Department of Fish and Game.*

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